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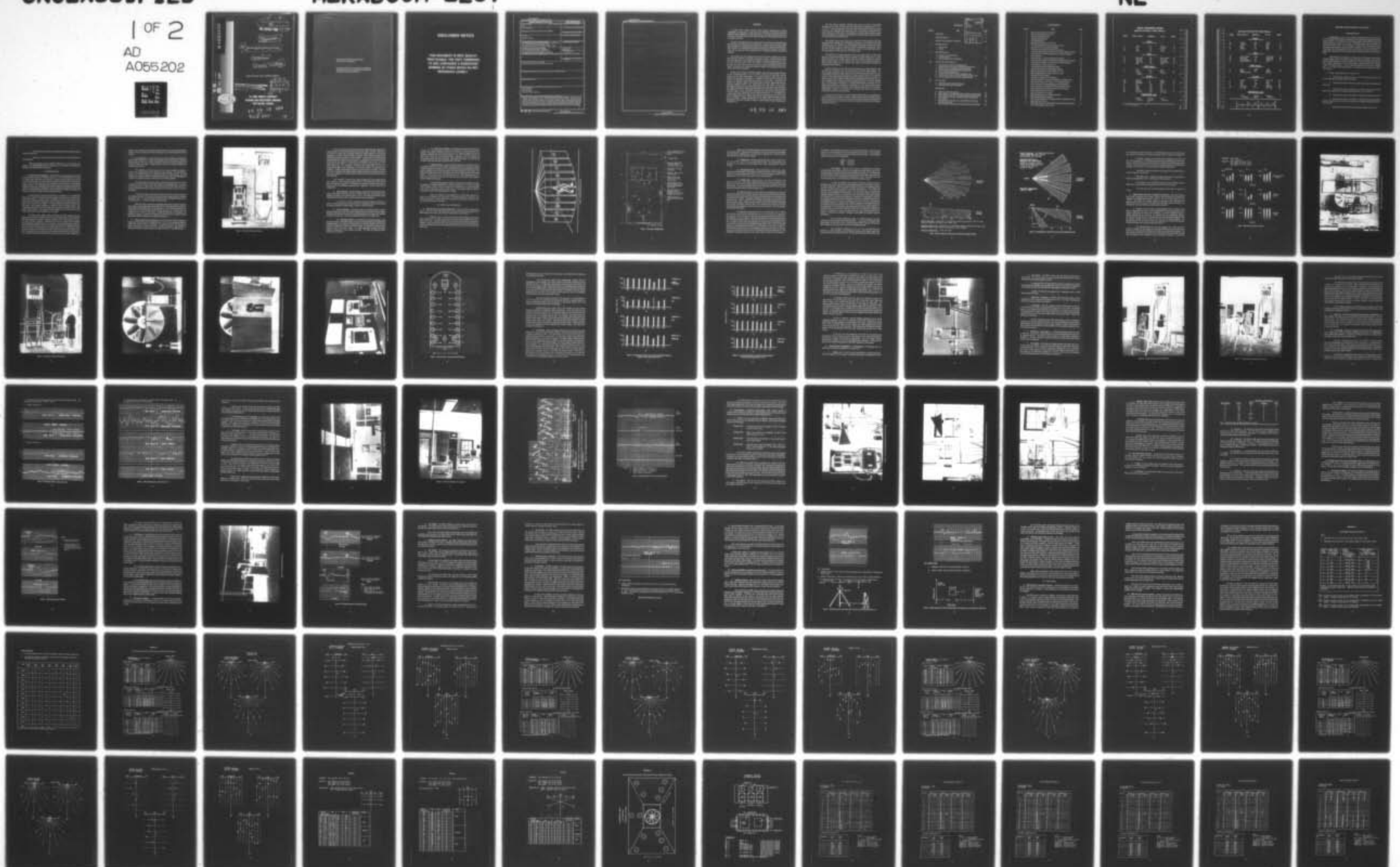

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(6) INFRARED MOTION SENSOR EVALUATION,

by

(10) William C. Garrett

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This report describes the test program performed by MERADCOM to determine the performance and reliability of model 19-115 Infrared Intrusion Sensor (IRIS). Three commercial infrared sensors were included in the test program to establish a base for comparing the test data. Each sensor was subjected to detection, nuisance alarms, electromagnetic interference (EMI), and temperature to determine each sensor's operating effectiveness when exposed to these conditions. The report describes each test performed and gives detailed performance data for each sensor.

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SUMMARY

A model 19-115 Infrared Intrusion Sensor (IRIS), manufactured by Barnes Engineering, was subjected to a series of tests to obtain data on the sensor's detection capability and susceptibility to false alarm stimuli. This report describes these tests, presents the test results, and includes suggestions relating to the electronic and mechanical design of the IRIS.

In order to establish a basis for comparison of the test data, three additional commercial sensors were included in the test program. Infrared sensors, such as the IRIS, detect intrusions by sensing thermal changes occurring in the sensors multiple fields of view; therefore, the temperature and infrared characteristics of the target, test environment, and the contents of the environment have a substantial influence on detection capability.

The specific test data obtained include sensor detection envelopes for various sized intruders, direction of intrusion, and intruder velocity. Intrusion detection data were also obtained in an environment maintained at stabilized temperatures of -20°, 0°, +25°, +50°, +70°, +98°, +120°, and +140° F. Sensor susceptibility tests included the effects of false alarm stimuli such as heating and air conditioning systems, space heaters, fluorescent and incandescent lighting, sunlight, electromagnetic interference, insects, and structural vibrations.

During the test program, the IRIS exhibited a high detection capability throughout the temperature range of -20° to +140° F; however, the false alarm rate was excessive at the higher temperatures. For example, during a period when the test facility heating plant was operating at a high-duty cycle, because of unusually cold weather, the IRIS false alarm rate was in excess of six per hour. During the same period, two Infralarm sensors (also manufactured by Barnes Engineering) having a detection capability similar to the IRIS produced no false alarms. In fact, Infralarm sensors produced no false alarms during the 6 months the sensors were monitored. The IRIS and Infralarm sensors optical geometry and detection circuitry is similar. The IRIS differs in that a thermally controlled gain circuit is used to increase sensitivity for a range of temperatures centered approximately at 98° F. The IRIS also has a much longer window time; that is, to be detected, an intruder must cross the boundaries of one field of view or adjacent fields of view within 20 seconds versus 5 seconds for the Infralarm. Further optimization of the thermal gain and detection time parameters is therefore necessary to achieve a better balance between detection and false alarm rate.

The IRIS self-test capability, whereby each of the ten sensors is periodically irradiated and an alarm output verified, functions reliably at temperatures of -20° F to +140° F. This technique does not detect a simple countermeasure, such as covering of the lens with transparent tape, black paint, etc., and would be a serious deficiency where this type of threat exists. The addition of a remote stimulus source for each sensor, although more complicated and difficult to install and align, would be required to detect obstruction countermeasures.

For multiple sensor head systems such as the IRIS the identification of the false alarming sensor, especially when the alarms are infrequent, can be a difficult and time-consuming task. The addition of a latching light emitting diode (LED) in the control unit for each sensor head, in conjunction with the appropriate entrance/exit timers and reset circuitry interfaced to the access/secure control, would significantly reduce the time required to locate the source of the false alarms.

The addition of an analog test point for each sensor head would be a major installation aid in selecting sensor locations to achieve a low false alarm rate. In many instances, because of a conflict between detection coverage requirements and false alarm stimulus within the sensor field of view, the lack of an analog test point to observe sensor response to the stimulus may require a trial-and-error technique in selecting the sensor locations.

Further refinements in the IRIS mechanical design and packaging could be made to reduce the installation labor requirements and to improve maintainability. The present IRIS sensor head design does not permit angular adjustment without the use of an additional platform and provisions for unions or swivel joints in the connecting conduit. The resulting piping complications make installation difficult and costly. A better technique used by Barnes Engineering for their Infralarm sensor makes use of a basic enclosure with a ball-jointed section containing the optics. Although the IRIS has an explosion-proof requirement, a suitable ball-and-socket arrangement for the optical system should be achievable at a reasonable cost. The ability to make angular adjustments of the sensor is desirable, since it permits moving the area of coverage to accommodate changes in the location of the contents of the zone or to avoid items installed later that may cause false alarms.

In many areas, the failure of a sensor system presents serious security problems, and rapid repair of the sensor is essential. Additional refinements to the IRIS, such as plug-in circuit boards for both the control unit and sensor heads and the relocation of the terminal boards in order to make them more accessible, would improve the maintainability of this item.

CONTENTS

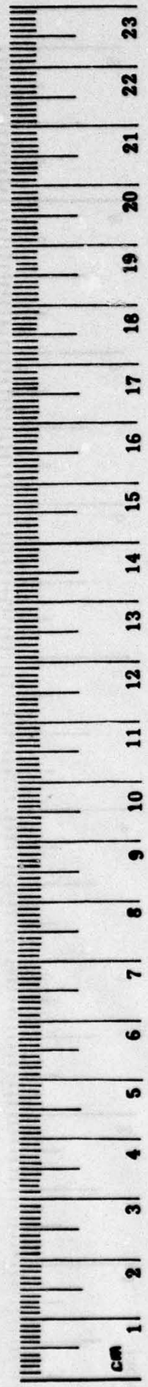
ILLUSTRATIONS

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

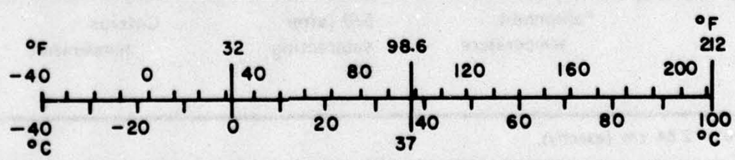
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric tons	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 cm (exactly).



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10 000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric tons (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



INFRARED MOTION SENSOR EVALUATION

I. INTRODUCTION

1. **Background.** The U.S. Army Mobility Equipment Research and Development Command (MERADCOM) was tasked by Sandia Laboratories to perform an engineering evaluation of a Model 19-115 Infrared Intrusion Sensor (IRIS) developed by Barnes Engineering, Stanford, Connecticut. The IRIS is unique in that it consists of 10 independent sensor heads, each containing an optical system, thermopile detector, signal processing amplifiers, and logic circuits. In addition, each sensor head periodically generates self-test commands to verify that the sensor can detect an intrusion. A single control unit provides the direct-current power and line supervision to each sensor head.

MERADCOM recommended to Sandia personnel that several commercially available infrared sensors be included in the test program to establish a basis for comparing the IRIS performance, since infrared sensor detection and false alarm performance is highly dependent on the test environment. Sandia supplied three additional commercial infrared sensors – two of a Barnes Engineering unit called the Infralarm and one of a Model 6400 manufactured by Advanced Devices Laboratory, (ADL), Reno, Nevada.

2. **Scope.** Engineering tests were conducted to:

a. Determine the detection envelope in a 70° F environment for each sensor system using two different sized human targets.

b. Determine the effects of intruder velocity on detection performance for each sensor.

c. Determine the detection performance for each sensor using a human target in an environment at stabilized temperatures from -20° F to +140° F.

d. Determine the sensors susceptibility to thermal and forced-air currents.

e. Determine the sensors susceptibility to conducted and radiated electromagnetic interference when tested in accordance with Military Standards MIL-STD-461A and 462.

f. Monitor each sensor system for false alarms during non-duty hours.

g. Identify false alarm sources not associated with air currents or electromagnetic interference.

h. Perform an electronic circuit and mechanical assembly evaluation on the IRIS system.

With the exception of the stabilized temperature tests, which were conducted in the MERADCOM Climatic Laboratory, the evaluation was conducted in Building 2093, MERADCOM North Annex.

II. INVESTIGATION

3. **General Test Considerations.** The Infralarm and ADL sensors were received in an operational condition. During the initial check-out of the IRIS system, 4 of the 10 sensor heads were found to be defective. Integrated circuit failures had occurred in 3 of the sensor heads. Failure of the thermal detector assembly had occurred in the fourth. Two of the sensor heads with integrated circuit failures were successfully repaired in-house. The remaining sensor heads required the specialized repair services of Barnes Engineering. Oral estimates from Barnes Engineering indicated that the total repair cost would approach $1,000.00. Sandia declined to authorize the repairs, and the test was revised to include the 8 remaining sensor heads.

Infrared intrusion detection performance is dependent on the background viewed by the detector, the intruder and his clothing, the time of day, and many other factors that change in a random manner. In addition, since false alarms are generally single events occurring on an infrequent basis, all sensors should continuously view as much of the same scene as possible. To achieve this goal, the IRIS, Infralarm, and ADL sensors were clustered together on a single test fixture mounting surface. This configuration permitted the optical systems for all sensors to be within a 7-inch radius of the cluster midpoint. The average mounting height for each sensor was 9 ft, well within manufacturer recommendations for each sensor.

The IRIS system differed from the Infralarm and ADL sensors in that the IRIS has the capability to perform a self test on each sensor head. Each sensor head periodically generates a self-test command, typically every 15 to 20 minutes, to verify the sensor detection capability. During this test cycle, the sensor head is inhibited from processing an intrusion alarm for 35 seconds. Test data (Appendix A) indicated that if three sensor heads were used to view the same scene, the probability of simultaneous self tests occurring on the three sensor heads was low. In addition, since the previous test history of the IRIS was not known and, since failures had occurred, there was a possibility that the sensitivity of some sensor heads may have been degraded. The remaining IRIS sensor heads and the control unit, because of their weight, were

mounted on a wheeled cart to facilitate their movement to the various test locations. Figure 1 shows the sensor mounting configuration on the sensor stand and cart test fixtures.

4. Instrumentation. A strip chart event recorder continuously monitored the alarm output terminals of the IRIS, both infralarms, and the ADL sensors. During the normal work day, the chart recorder remained in operation to verify the ability of the sensors to detect intrusions. During non-duty hours, the recorder monitored the sensors for false alarms.

The Infralarm and ADL sensors did not have accessible test points to monitor the analog signals from the thermal detector amplifiers. The electronics circuitry of the Infralarm sensor was completely sealed in a plastic housing. The ADL amplifier was similarly sealed in a cylindrical metal housing. The risk of damage to the sensors was considered too great to attempt entry into these enclosures.

The IRIS sensor heads had readily accessible test points that were used to examine the sensor response to false alarm stimuli. The analog test point was reserved for individual tests on a single sensor head, disconnected from the IRIS control unit, because attaching long leads to sensitive portions of the circuitry could be a source of false alarms.

A multipoint thermocouple chart recorder was used to monitor and record the internal temperature of the various sensor electronics packages during the stabilized temperature tests. The environmental test chamber wall and ceiling temperatures were also monitored at 12 locations by using a similar recorder.

IRIS false alarms, experienced in Building 2093 during a period of unusually cold weather, required additional instrumentation to monitor and record the floor-to-ceiling temperature gradient and duct air temperature. The temperature gradient was measured by five fast-responding thermocouples mounted on a wooden pole that extended from the floor to the ceiling. A single thermocouple was installed in the heating duct register to measure the exhaust air temperature and to correlate the IRIS false alarms with the operation of the building heating plant.

5. Infrared Motion Sensor Operation. All matter generates infrared radiation at temperatures above absolute zero degrees Kelvin (-273° C), this radiation is similar to visible light, differing only in wavelength. The infrared spectrum lies between the longest wavelengths of light (red) and the shortest microwaves. The spectrum of infrared wavelengths is generally defined as existing between 0.7 and 1000 microns.

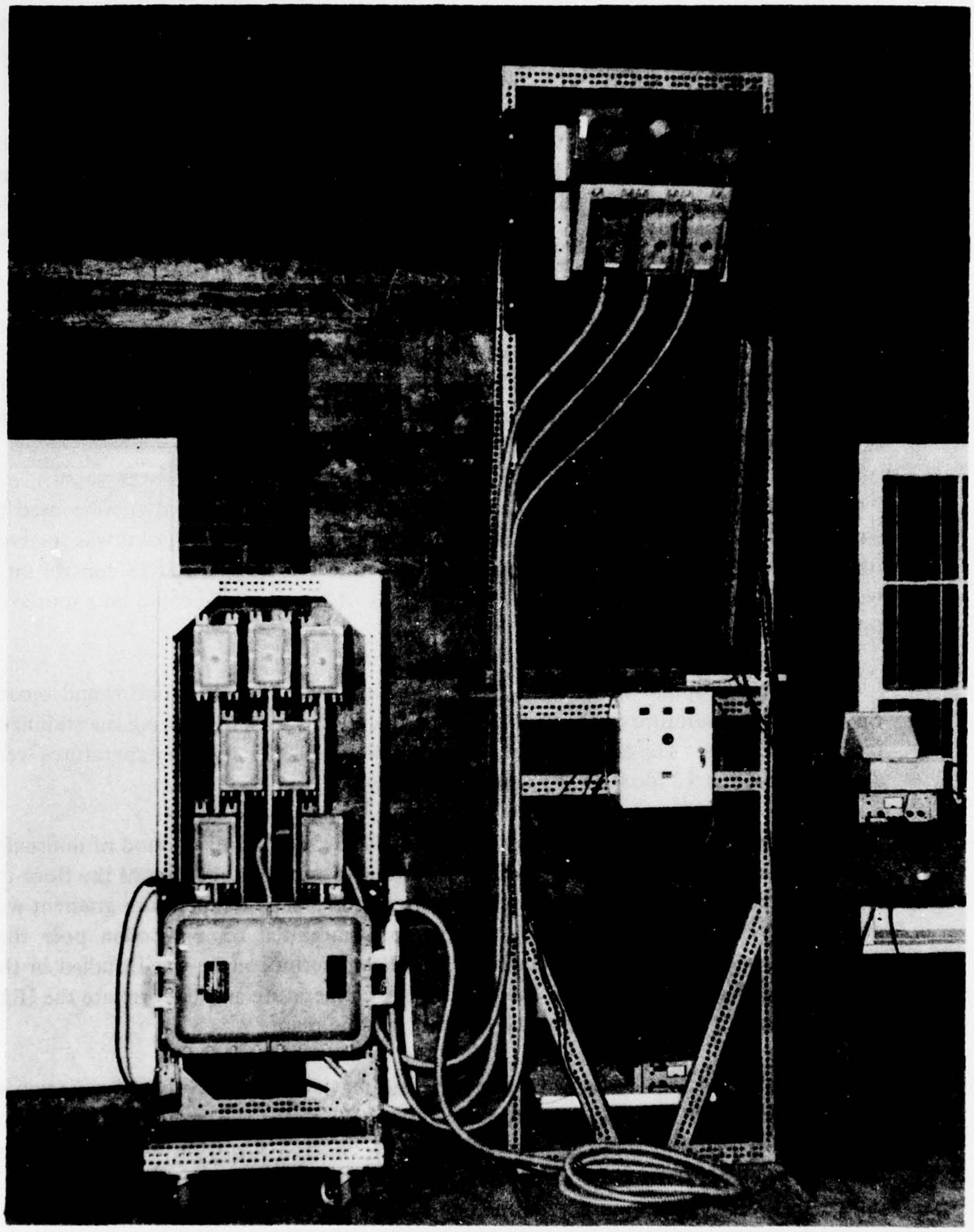


Figure 1. Sensor stand and cart test fixtures.

The amount and spectral characteristics of the infrared energy radiated by an object depends on its absolute temperature and surface finish. The term "black body" is used for any object which completely absorbs all incident radiation or, at any given temperature, the most efficient radiator of energy. Most objects in nature are not perfect black bodies; therefore, the term emissivity is used to define the radiating and absorbing efficiency referenced to a black body. Lampblack, for example, is an efficient absorber and radiator of energy with an emmissivity close to one. A silver or aluminum surfaced mirror is a poor radiator and absorber of energy with an emissivity close to zero. The emissivity of metals at room temperature is low, but it increases substantially as the temperature of the metal is raised. For non-metals, the emissivity is high and generally decreases as the temperature is increased. The radiation from metals and other opaque surfaces originates within a few microns of the surface, hence emissivity is a function of the surface state of the material rather than its bulk properties.

The emissivity of human skin is high, averaging 0.99 at wavelengths greater than 4 microns. In an indoor environment (70° F), the temperature of the exposed skin on the face and hands is 90° F, clothing further reduces the energy incident on the detector, since the resulting temperature and emissivity are lower than that of exposed skin.

a. **Optical Systems.** Infrared motion sensors collect and focus the radiant energy using either a system of refractive or reflective optics. In some instances a combination of reflective and refractive optics is used. The IRIS and Infralarm sensors used refractive optics; the ADL, a reflective system of mirror segments.

For objects at room temperature, the peak radiance occurs at 10 microns. Optical filters are often used to reduce the background noise level by limiting the detector response to infrared energy in the 8- to 14-micron region.

b. **Detector Elements.** Thermal detectors are commonly used in infrared intrusion sensors to convert the incident radiation into proportional electrical signals. This group of detectors responds to the incident radiation by a change in the electrical property of the detector. Two types of thermal detectors are in common use:

(1) **Thermopile Detector.** Thermopiles are constructed using a series of thermocouples. Each thermocouple consists of a pair of thermoelectric junctions of dissimilar metals. One junction is shielded from the incident radiation, and the other junction is blackened to absorb the infrared energy; the difference in junction temperature produces an output voltage. For small temperature changes, the output voltage is proportional to the temperature change. The IRIS and Infralarm sensors used this type of detector.

(2) Thermistor Bolometer. Semiconducting oxides are used to form a material with a high-temperature coefficient of resistance. To provide ambient temperature compensation, thermistor pairs are used in a bridge arrangement with one thermistor shielded from the incident radiation. The type of detector used by the ADL sensor could not be determined since schematics were not available and attempted access to the detector circuitry could damage the sensor. The low cost of the ADL sensor indicates that a thermistor device was used.

c. Signal Processing. Since the thermal background in the field of view of an infrared intrusion sensor is constantly changing because of air movement, environmental temperature fluctuations, etc., the sensor must be able to discriminate between thermal variations due to the environment and those produced by an intruder. The IRIS and Infralarm sensors divide the field of view into 10 separate sectors, as shown in Figure 2. Each sector has its own thermopile detector. These thermopiles are connected series opposing so that when the intruder crosses the field of view, alternate polarity voltages are produced.

The thermopile signals are further processed by the amplifiers to limit the response to velocities possible by an intruder, typically 0.1 to 25 ft/s. The IRIS requires that the intruder cross two adjacent sector boundaries or the same boundary twice within 20 seconds to produce a sensor alarm. The Infralarm differs in that the crossings must occur within approximately 5 seconds.

Since no schematics were available for the ADL sensor and the circuitry was not accessible, the exact nature of the signal processing is not known. The ADL sensor appears to detect intrusions by sensing the thermal rate of change occurring in the field of view of the sensor.

III. TESTS AND TEST RESULTS

6. Infrared Sensor Detection Envelope Tests. The low-velocity intrusion tests (4 in/s, 3 ft/s, and 6 ft/s) were conducted to determine the detection envelopes of the IRIS, Infralarm, and ADL sensors with the sensor stand at test location A.

a. General. Figure 3 depicts the floor plan of the building and the sensor stand test location. The open area in front of the sensor stand is approximately 45 ft long by 30 ft wide. Assorted cabinets and benches are located along the walls of the building. This nonuniform thermal scene tends to improve the detection performance because the intruder obstructs these localized thermal sources as he crosses the sensor field of view.

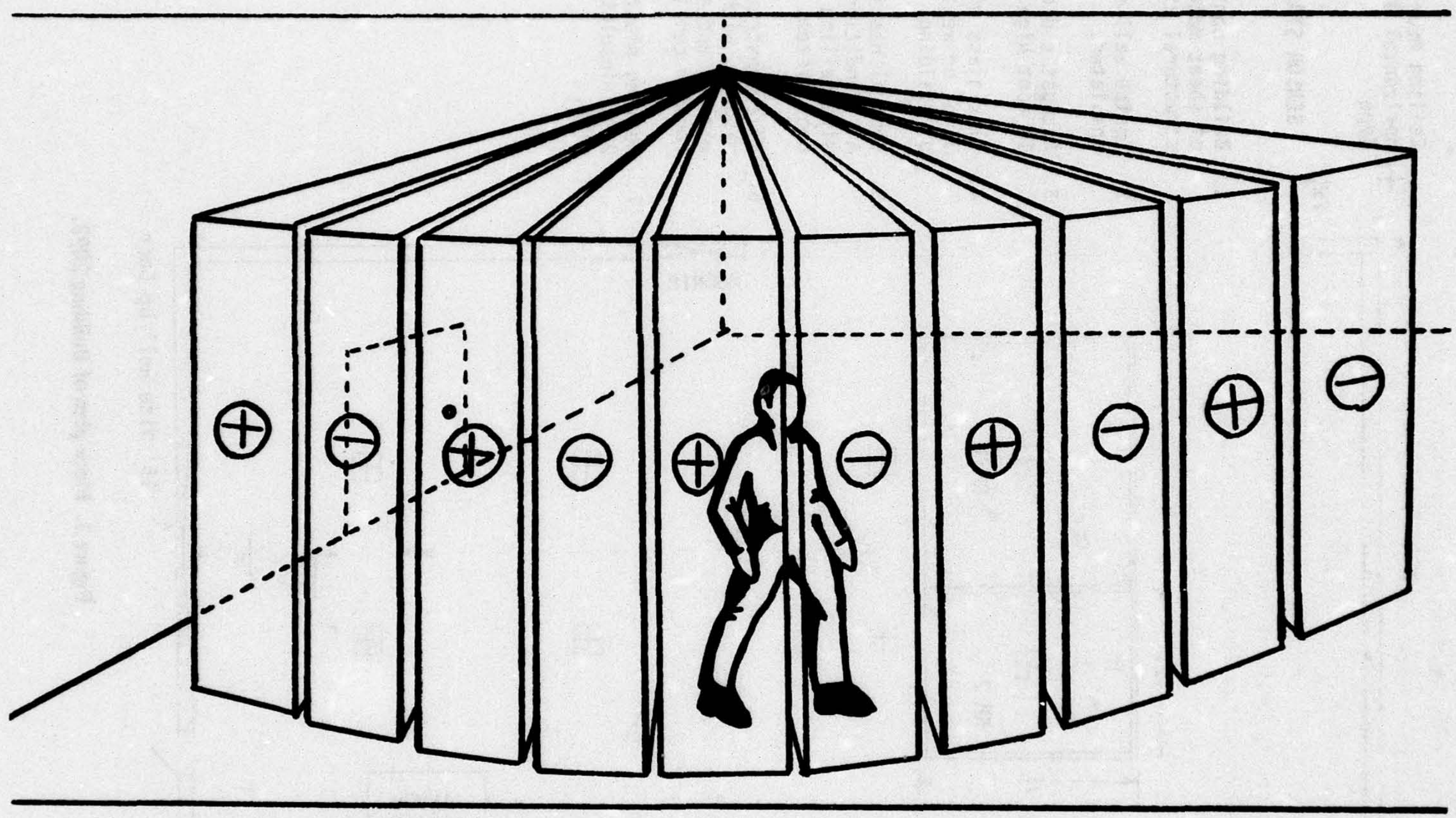
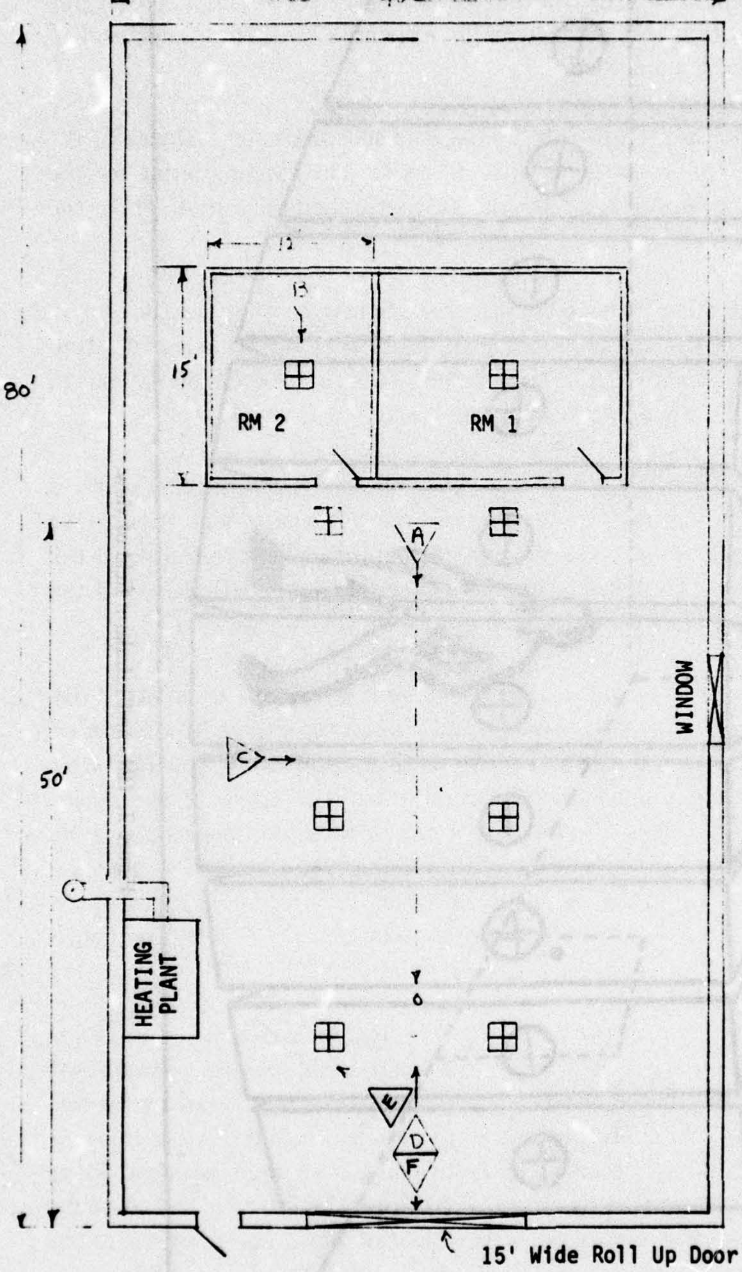


Figure 2. IRIS and Infralarm field of view.



Ceiling Mounted Register, Horizontal Diffusing Type

FWD

SENSOR STAND

1. Building constructed of sheet metal to structural steel frame.
2. Inside wall surfaces insulated.
3. Accoustic drop ceiling 14 foot high.
4. Plexiglass window 3'x6' on west side of building.
5. Central Heating and Air Conditioning plant with ceiling mounted duct system.
6. RM 2 constructed of masonry, with no windows and a centrally located ceiling vent.
7. Heating plant has a 9" un-insulated chimney pipe.

Figure 3. Floor plan of Building 2093.

Three types of intrusion paths are marked off on the floor area in front of the sensor stand. These paths are referenced to the sensor stand and a zero-degree axis (centerline of building) (see test data sheets in Appendix B). The paths used to determine the detection envelope included:

(1) **Radial Paths:** Paths intersecting the sensor stand at angles of 0°, 15°, 30°, 45°, 60°, and 75° on both sides of the 0° axis. The starting point for the intrusions was 15 ft from the sensor stand for the 75° path, increasing to 45 ft for the 0° path.

(2) **Perpendicular Paths:** Paths perpendicular to the 0° axis. Intrusions were performed from both directions, starting 15 ft from the 0° axis and terminating 15 ft on the opposite side of the 0° axis. The paths intersected the 0° axis at distances of 6, 12, 18, 24, 30, 36, and 45 ft from the sensor stand.

(3) **Parallel Paths:** Paths located 3, 6, 9, and 12 ft parallel to both sides of the 0° axis. Two intrusion starting locations were used for each path. One location was 45 ft from the sensor stand with the direction of intrusion toward the sensor stand. The second starting location was at the sensor stand 90° axis, and the direction of intrusion was away from the sensor stand.

The IRIS, Infralarm, and ADL sensors were interfaced to an alarm display that provided visual and audible indications when the sensor detected the intruder. The testing sequence began with the intruder positioning himself at the starting point of the path to be tested. Remaining motionless, the intruder waited for the sensor alarms to cease. Thirty seconds after the last alarm, the intruder proceeded down the path at the test velocity. When the sensor under test detected the intruder, he stopped and recorded his distance along the path. The intruder then returned to the path starting point and repeated the test for the next sensor to be tested. This test sequence was repeated for each path.

Two different sized intruders (5 ft 6 in., 160 lb; and 6 ft 2 in., 230 lb) were used for the low-velocity intrusion tests (4 in./s, 3 ft/s, and 6 ft/s). Because of the small size of the test area, the high-velocity intrusions presented some problems. For example, it was not possible to run along the radial path, since the intruder could not run under the sensor stand nor could he start his run out of the sensor's field of view. In order to test a sensor using high-velocity intrusions, the intruder had to be up to speed before entering and after exiting the sensor field of view. In lieu of the radial intrusions, two diagonal-path intrusions were performed in test location C (Figure 3). This location was also used for the perpendicular intrusions, since there was sufficient room out of the sensor's field of view for the intruder to start and stop his run. The parallel-path intrusions required that the sensor stand be moved to test location A.

In addition, the garage door was raised 6 ft to permit the intruder to exit the sensor field of view when starting his run from behind the sensor stand. A much smaller intruder (5 ft 5 in., 135 lb) was used for the high-velocity intrusion. This individual reliably maintained three running speeds:

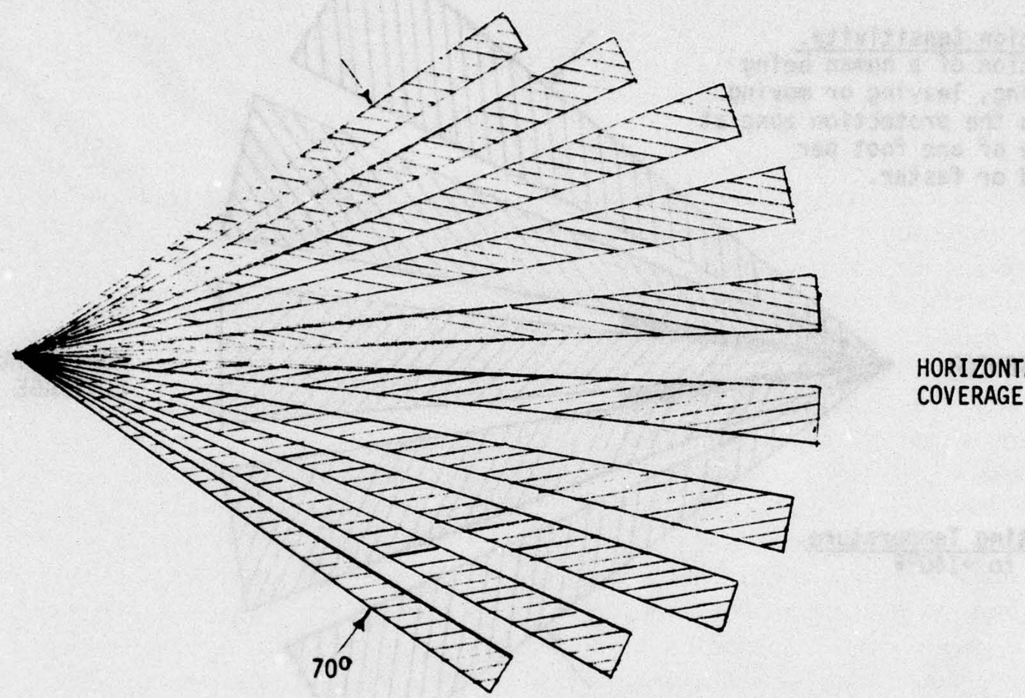
HIGH – 20-23 ft/s.
MED – 14-16 ft/s.
LOW – 10-12 ft/s.

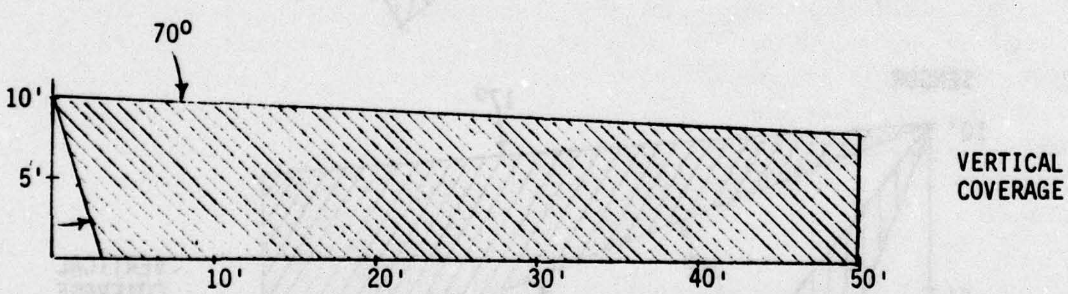
b. **Test Results.** Figures 4 and 5 show the manufacturers' published horizontal and vertical fields of view for the Infralarm and ADL sensors. Other pertinent specifications for these sensors are also included in these figures. The IRIS technical manual did not state the operational characteristics of the sensor other than that the sensor head has a 70° horizontal and vertical field of view. The field of view and sector geometry appear to be identical for the IRIS and Infralarm sensors.

In order to determine the maximum detection envelope size for an infrared sensor, the test area must be substantially larger than the maximum range of the sensor under test. Based on previous experience, the test area should be at least twice the maximum range specified by the sensor manufacturer. For the IRIS and Infralarm sensors, this would require a test area at least 100 ft long. A suitable area this size was not available for this evaluation. The detection envelopes (Appendix B) obtained represent the area of coverage the sensors can provide in the space available (45 ft long by 30 ft wide) for this evaluation. In addition, it is important to note that the detection envelopes included in Appendix B represent each individual sensor detection performance for a given set of conditions at the time of the test. Relocation of the building contents or a change in the building temperature could produce substantial changes in the size and shape of the detection envelope for the same intruder. As the temperature of the background scene approaches the intruder's body temperature, intrusion detection becomes more difficult and the size of the detection envelope will decrease. Fortunately, in most environments there are large thermal gradients and a variety of contents with differing emissivities that enhance the sensor's detection performance.

For the optical configuration used on the IRIS, Infralarm, and ADL sensors, low-velocity intrusion detection performance is maximum for intrusion paths perpendicular to the field of view. Radial intrusions result in the least temperature rate of change for the sensors and, therefore, the minimal detection.

For low-velocity intrusions (4 in./s to 6 ft/s), the IRIS detection envelopes for radial, parallel, and perpendicular intrusions were slightly larger than those obtained for the Infralarm sensor. The detection envelopes for the ADL sensor





Area of Coverage. Sensor has a 70 degree horizontal and vertical field of view; detection range of 50 feet on the center line.

Detection Sensitivity. Detection of a human being either crossing the same sector boundary twice or two adjacent boundaries within 5 seconds.

Operating Temperature. +32°F to +120°F

Figure 4. Infralarm specifications. (Information extracted from the installation manual.)

Area of Coverage. The Model 6400 provides a tear shaped detection pattern approximately 20 x 20 feet.

Detection Sensitivity. Detection of a human being entering, leaving or moving within the protection zone at a rate of one foot per second or faster.

Operating Temperature. -20°F to +140°F

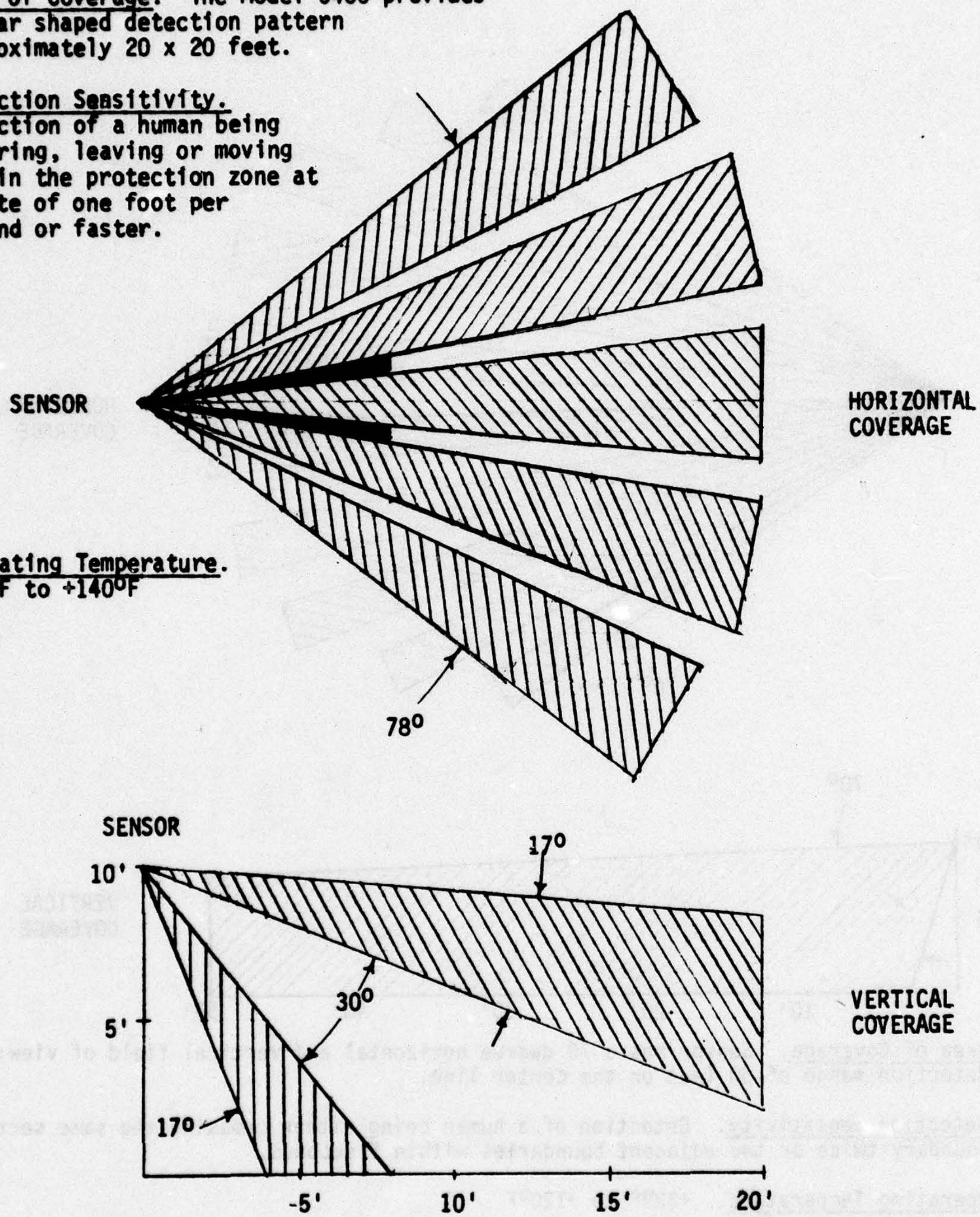


Figure 5. ADL Specifications. (Information extracted from the installation manual.)

were substantially smaller than those of the IRIS/Infralarm sensors. Test data sheets and detection envelopes for each type of intrusion path are included in Appendix B.

Detection envelopes for the high-velocity intrusions (10 to 20 ft/s) were not obtained since it is difficult using the previous procedures and instrumentation to accurately determine the distance from the sensor for the first detection of the intruder. The testing was therefore reduced to obtaining the sensors alarm/no-alarm response to each intrusion. Test data sheets are included in Appendix B.

Bar graphs summarizing detection percentages for the paths tested are shown in Figure 6 for each sensor.

The IRIS sensor provided the highest detection for perpendicular, parallel, and diagonal intrusions at velocities of 10 ft/s and greater.

The Infralarm sensor exhibited substantially lower detection than the IRIS sensor for perpendicular intrusions at velocities of 14 ft/s and greater.

The ADL sensor did not detect parallel-path intrusions at a velocity of 20 ft/s.

7. **Infrared Sensor Detection at Stabilized Temperatures.** The infrared sensors were tested to determine their ability to detect a human target in an environment maintained at stabilized temperatures of -20°, 0°, +25°, +50°, +70°, +98°, +120°, and +140° F. The largest test chamber capable of operating at these temperatures at MERADCOM is 32 feet long, 14 feet wide, and 13 feet high. Figures 7 through 11 are photographs of the test chamber and sensor stand orientation.

a. **General.** As can be seen in the photographs of the test chamber, many items are attached to the walls. In order to determine the detection performance of an infrared sensor under the most severe conditions, it would be desirable to present a uniform thermal scene to each sensor. To approach this goal of uniformity, plywood was placed in the aft end of the chamber to cover the fan assembly during the intrusion testing. Plywood was also used to cover the floor for the same purpose. The starting locations for the intrusion paths were stenciled onto this plywood flooring. The path directions and locations are shown in Figure 12.

The instrumentation for this test consisted of a strip chart event recorder to display the sensor alarms and a multipoint thermocouple chart recorder to monitor the thermocouples installed in each sensor system electronics package. The test chamber temperature was monitored by 12 wall-mounted thermocouples; a circular chart recording for each temperature tested is included in Appendix C. Prior to the

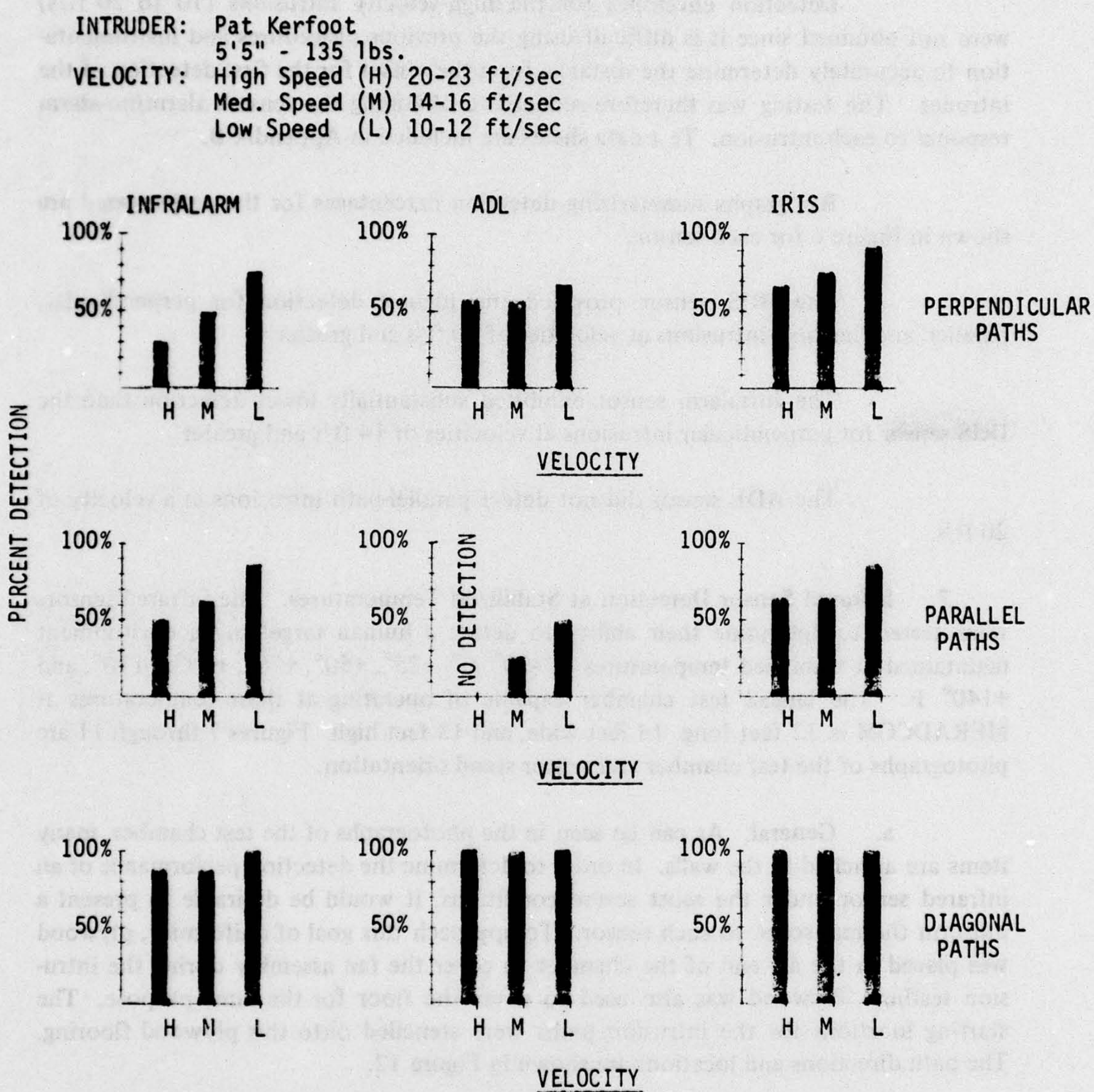


Figure 6. High-velocity intrusion test results.

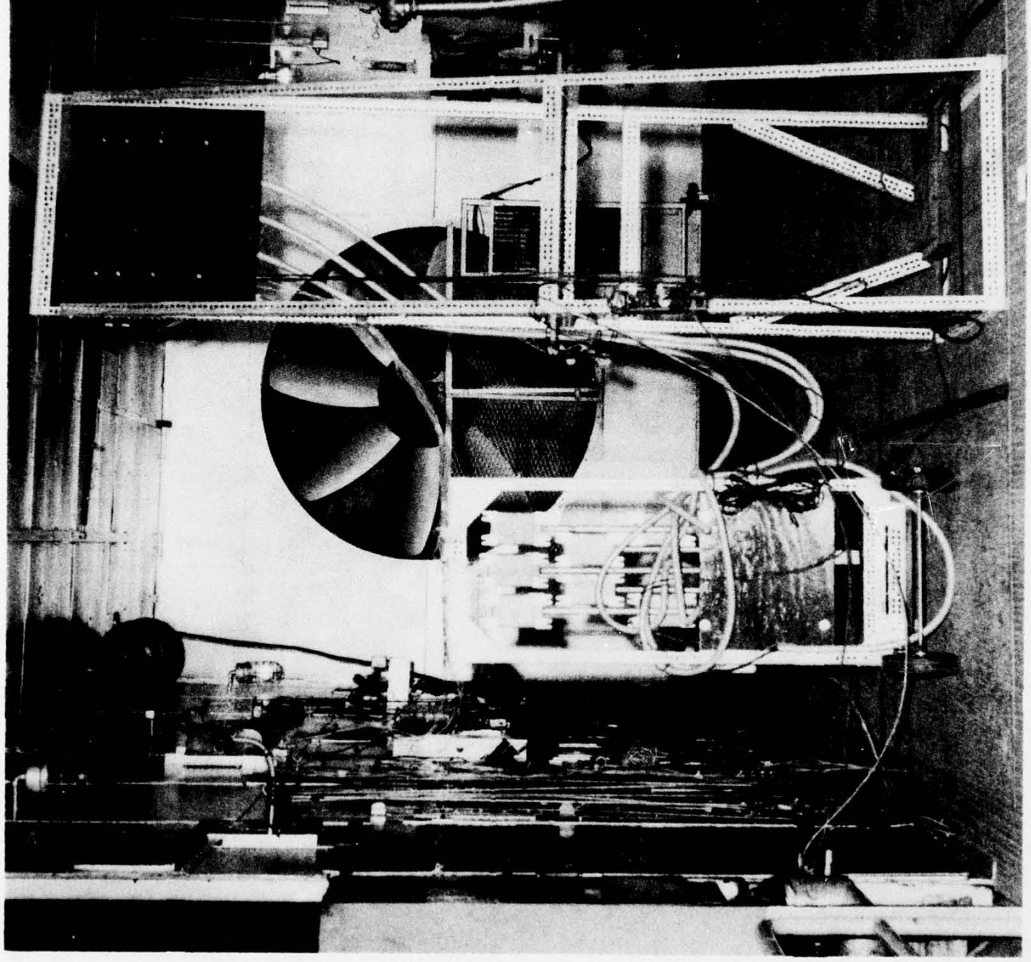


Figure 7. Environmental test chamber equipment layout.

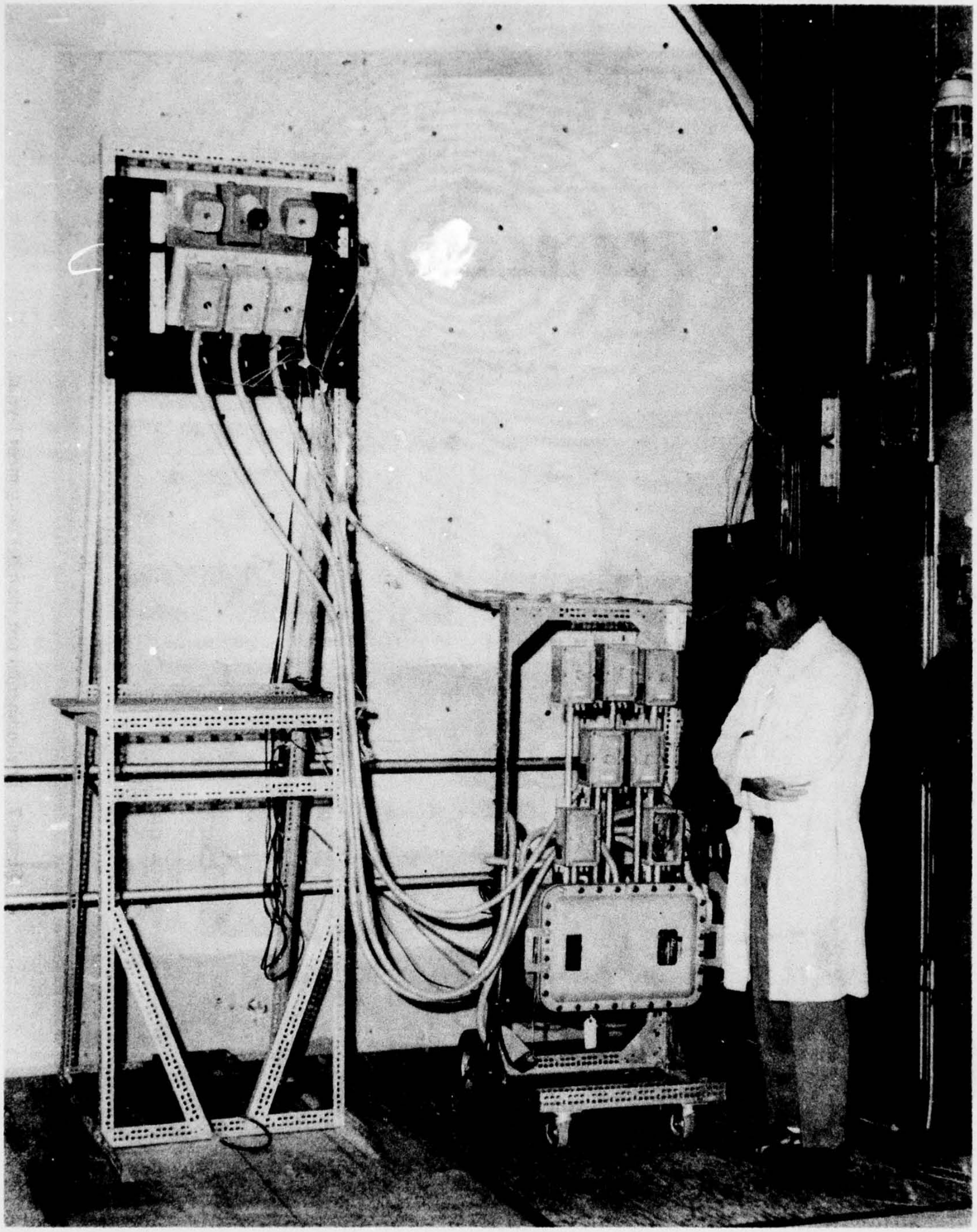


Figure 8. Forward end of environmental chamber.

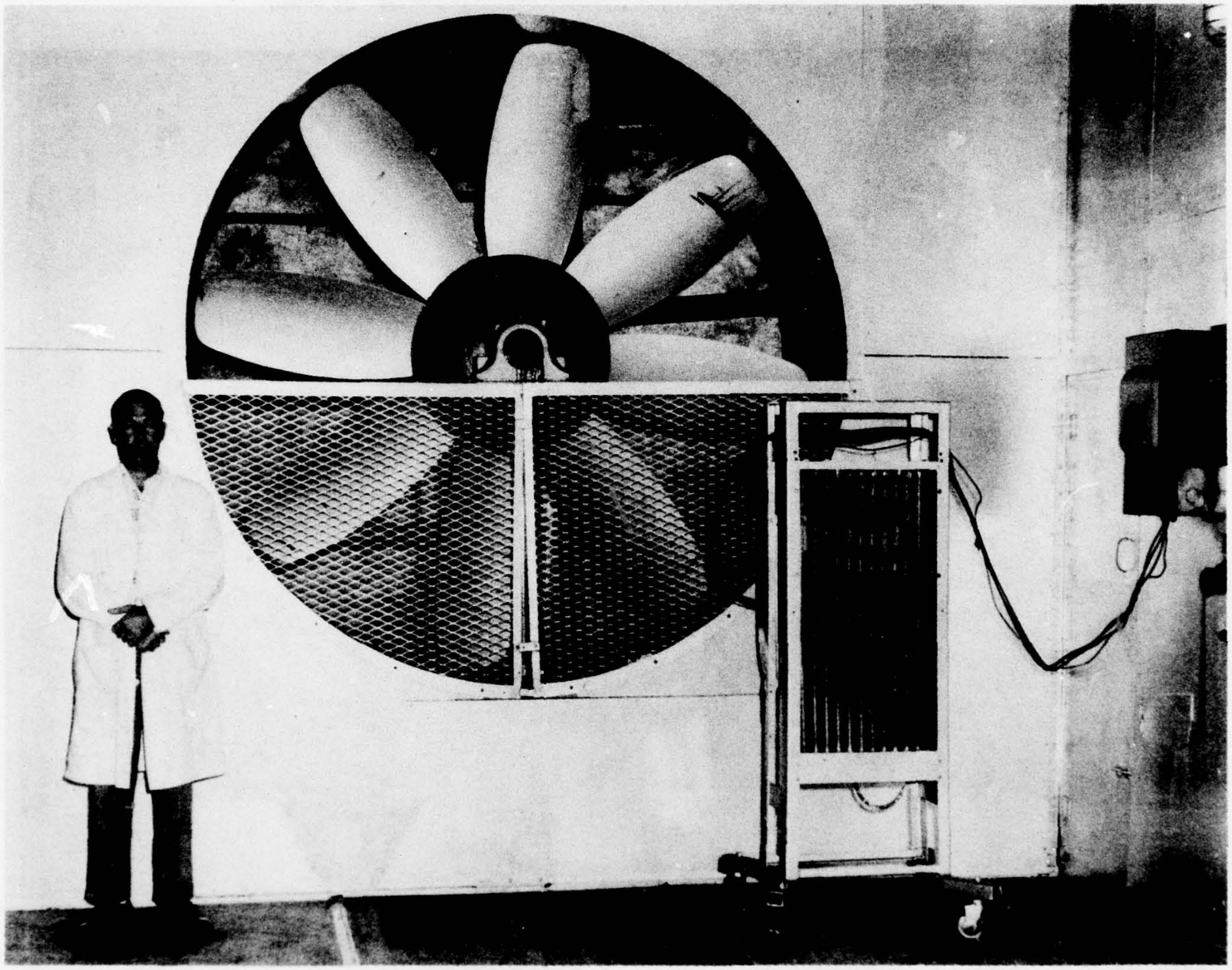


Figure 9. Environmental chamber 10-kW heater location.

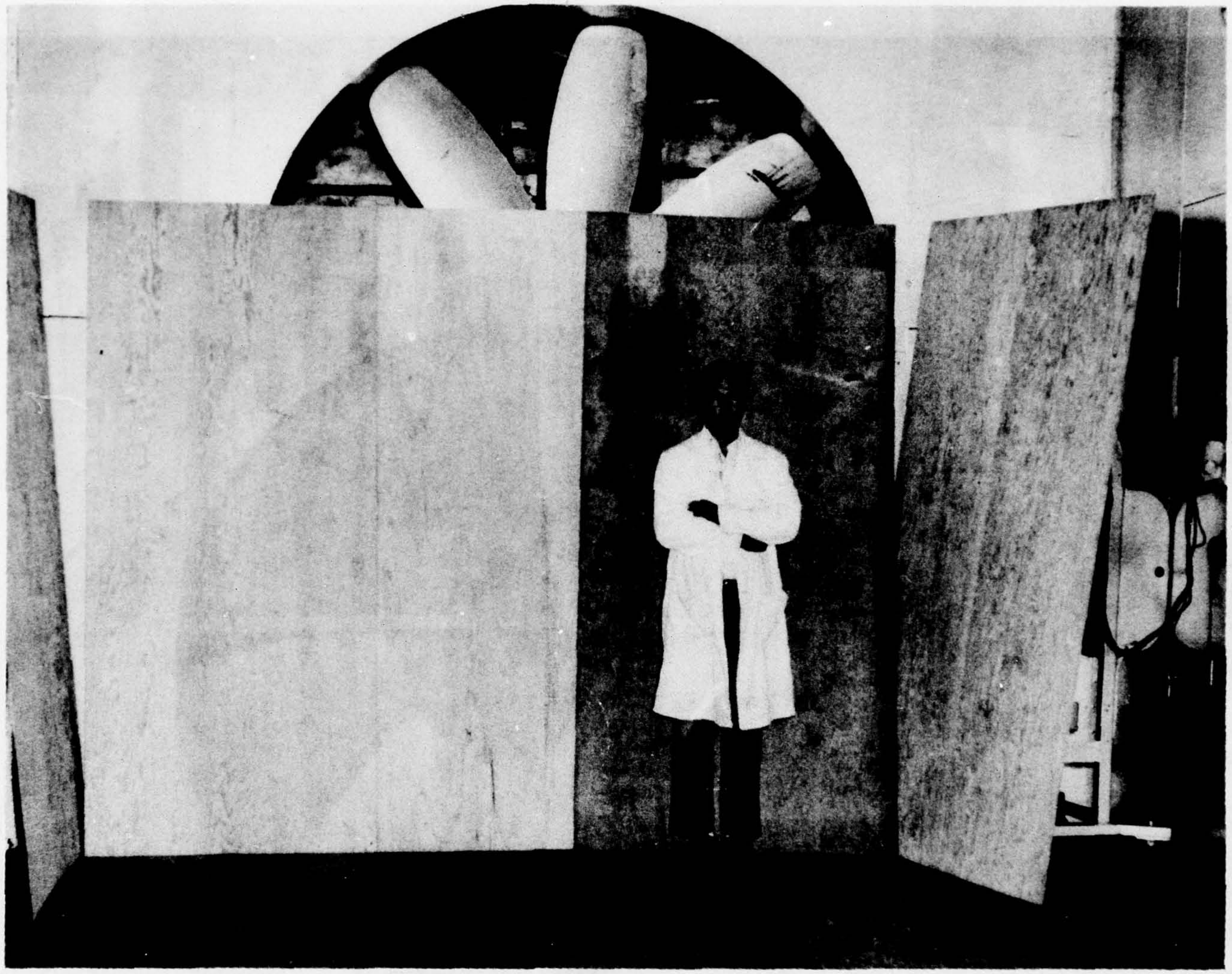


Figure 10. Aft end of environmental chamber prepared for intrusion testing.

Figure 11. Environmental chamber temperature and alarm monitoring instrumentation.

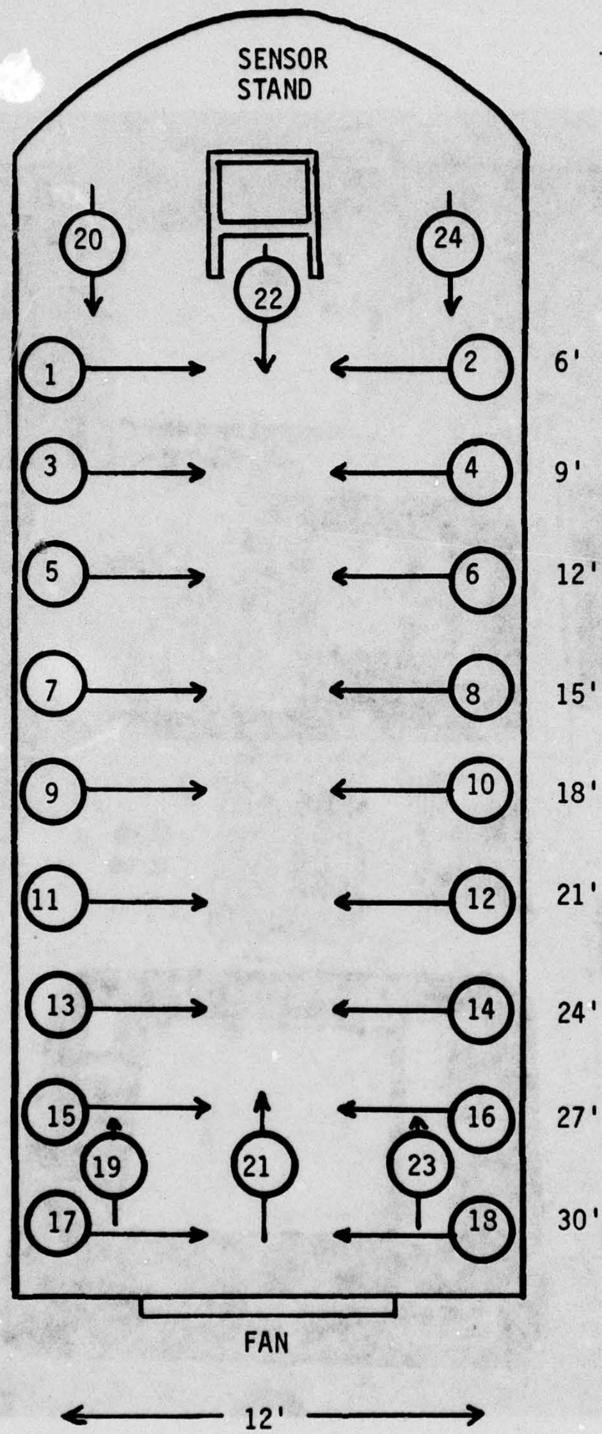


Figure 12. Intrusion paths – large environmental chamber.

intrusion testing, the test chamber was maintained at the stabilized test temperature for a minimum of 4 hours.

For the intrusion testing in the environmental chamber, the exact determination of the distance along the path where the intruder was detected was not deemed necessary. To obtain this measurement would require that the intruder stop for each sensor alarm, record his location, and return to the starting point to repeat the test for the remaining sensors. This process would subject the test data to the inability of the intruder to exactly repeat his body motions. In addition, since the chamber machinery must be turned off to perform the intrusion test, time is an important factor because of the lack of temperature control.

The same intruder performed all the intrusions. For temperatures of +25° F and above, the intruder wore normal street clothes; a long-sleeved shirt was worn to minimize exposure of the skin surface to the sensors. Below +25° F, the intruder wore an arctic outfit with hood and gloves.

One-half hour prior to the start of the intrusion test, the intruder entered the chamber to stabilize his surface temperature. At the end of this time the chamber machinery was turned off. The plywood panels, which had remained in the chamber, were then installed in the aft end of the chamber. The intruder then positioned himself at the starting point for path 1 and remained motionless until all the sensors ceased to alarm. Thirty seconds after the last sensor alarm, the intruder walked along the path at the 4-in./s velocity. As the sensors detected the intrusion, the technician manning the chart recorder annunciated the alarm sequence. If any sensor failed to detect the intrusion, the test was repeated at the 18-in./s velocity. This process was repeated for all 24 paths.

b. **Test Results.** When the background temperature approaches the target temperature, detection becomes difficult; therefore, the testing sequence was started at a chamber temperature of 98° F. The ADL sensor was the only unit that was appreciably affected by the 98° F environment. At a later date the test was repeated with a longer stabilization time (12 hours vs 4 hours). The longer stabilizing time resulted in the ADL sensor's complete loss of the ability to detect the intruder. At temperatures above and below 98° F, the IRIS, Infralarm, and ADL sensors exhibited good detection capabilities. The test data for each sensor are plotted in Figures 13 and 14 for both the perpendicular and parallel paths. When interpreting the test data, it should be noted that the ADL sensor is a short-range unit with a detection range of approximately 20 ft, compared to 50 ft for the IRIS and Infralarm sensors. Detection was almost identical for both Infralarm units. Although the Infralarm was only specified for operation at temperatures between +32° F and +120° F, the sensor detection was not affected by the temperature extremes of -20° F to +140° F.

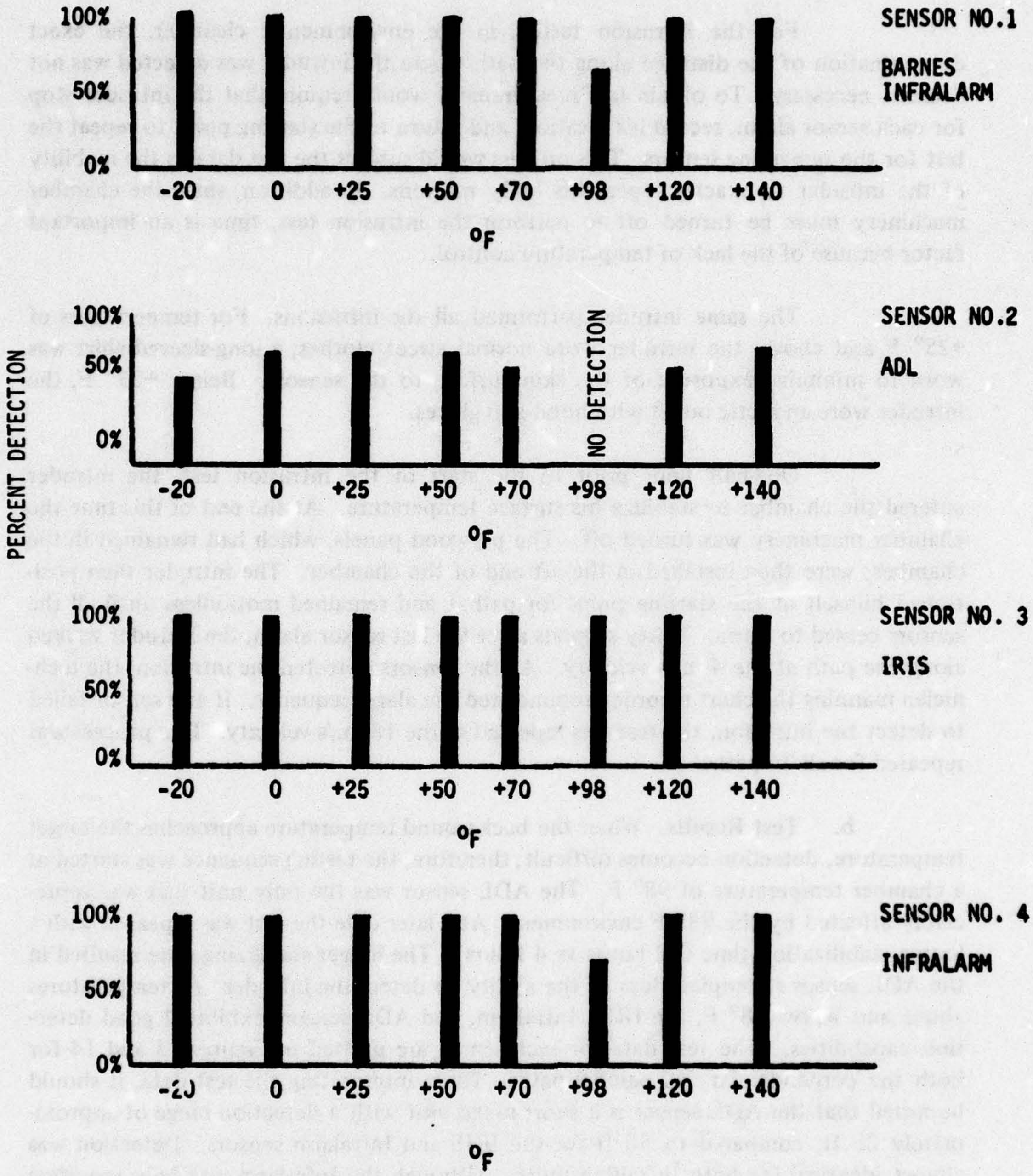


Figure 13. Environmental chamber test results for perpendicular intrusions. (Intruder velocity approximately 4 in./s)

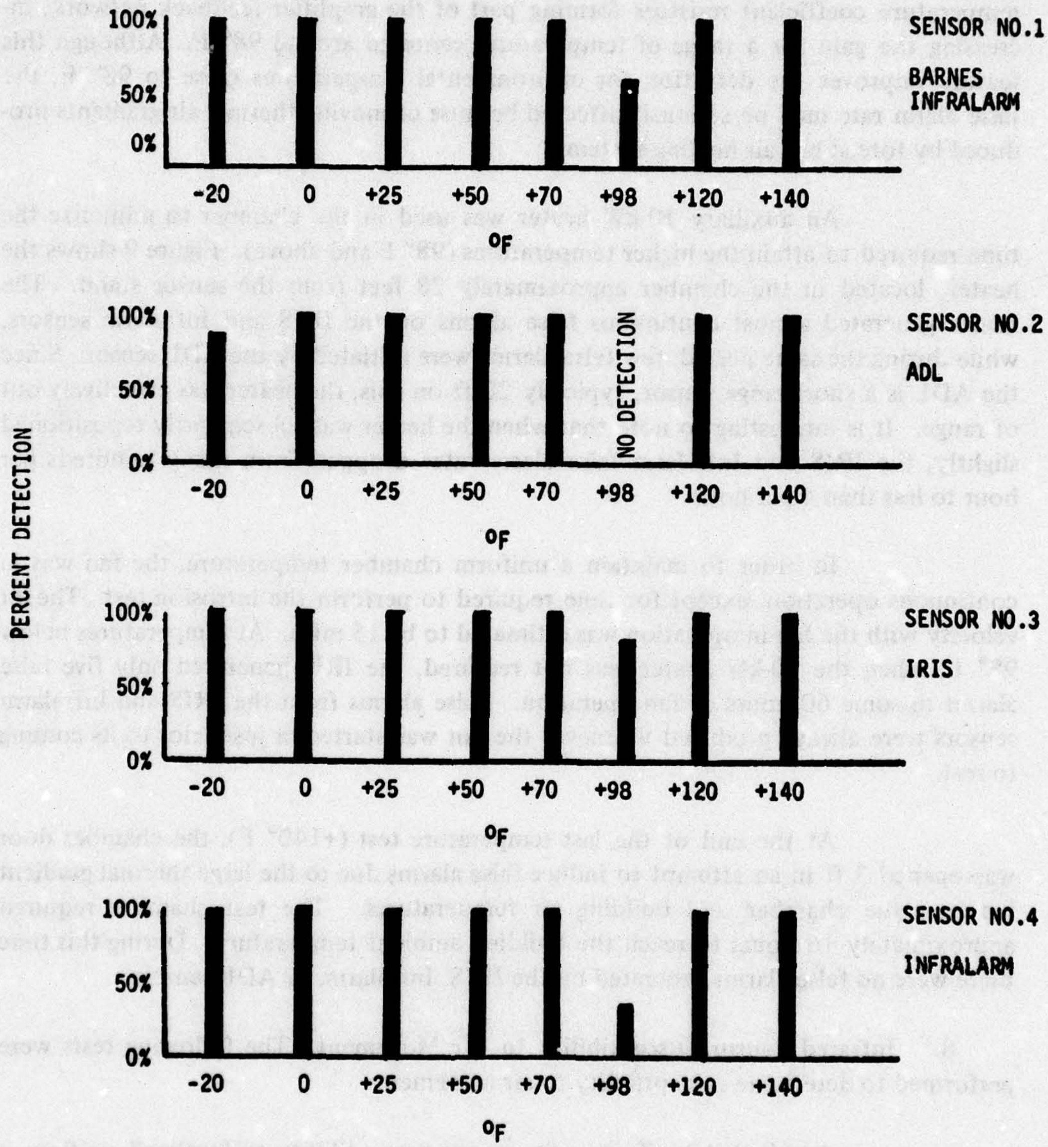


Figure 14. Environmental chamber test results for parallel intrusions. (Intruder velocity approximately 4 in./s.)

The IRIS sensor, at temperatures of +120° F and +140° F, was extremely sensitive to small body movements even when the intruder made a determined effort to minimize his body movement while waiting at the path starting point. As soon as he attempted to walk, the IRIS immediately alarmed. The probable reason for this high sensitivity was the use of a thermally controlled gain peaking network in the sensor thermopile amplifier. This was accomplished with positive and negative temperature coefficient resistors forming part of the amplifier feedback network, increasing the gain for a range of temperatures centered around 98° F. Although this feature improves the detection for environmental temperatures close to 98° F, the false alarm rate may be seriously affected because of moving thermal air gradients produced by forced hot-air heating systems.

An auxiliary 10-kW heater was used in the chamber to minimize the time required to attain the higher temperatures (98° F and above). Figure 9 shows the heater, located in the chamber approximately 28 feet from the sensor stand. The heater generated almost continuous false alarms on the IRIS and Infralarm sensors, while during the same period, few false alarms were initiated by the ADL sensor. Since the ADL is a short-range sensor, typically 20 ft on axis, the heater was effectively out of range. It is interesting to note that when the heater was subsequently repositioned slightly, the IRIS and Infralarm false alarm rates dropped from many hundreds per hour to less than 4 per hour.

In order to maintain a uniform chamber temperature, the fan was in continuous operation, except for time required to perform the intrusion test. The air velocity with the fan in operation was estimated to be 15 mi/h. At temperatures below 98° F, when the 10-kW heater was not required, the IRIS generated only five false alarms in some 60 hours of fan operation. False alarms from the IRIS and Infralarm sensors were always produced whenever the fan was started or just prior to its coming to rest.

At the end of the last temperature test (+140° F), the chamber door was opened 3 ft in an attempt to induce false alarms due to the large thermal gradient between the chamber and building air temperatures. The test chamber required approximately 16 hours to reach the building ambient temperature. During this time there were no false alarms generated by the IRIS, Infralarm, or ADL sensors.

8. **Infrared Sensor Susceptibility to Air Movement.** The following tests were performed to determine susceptibility to air movement:

a. **Ambient Air.** To test for sensor susceptibility to localized air flow, a ducted fan (Figure 15) was placed at various locations across the sensor field of view.

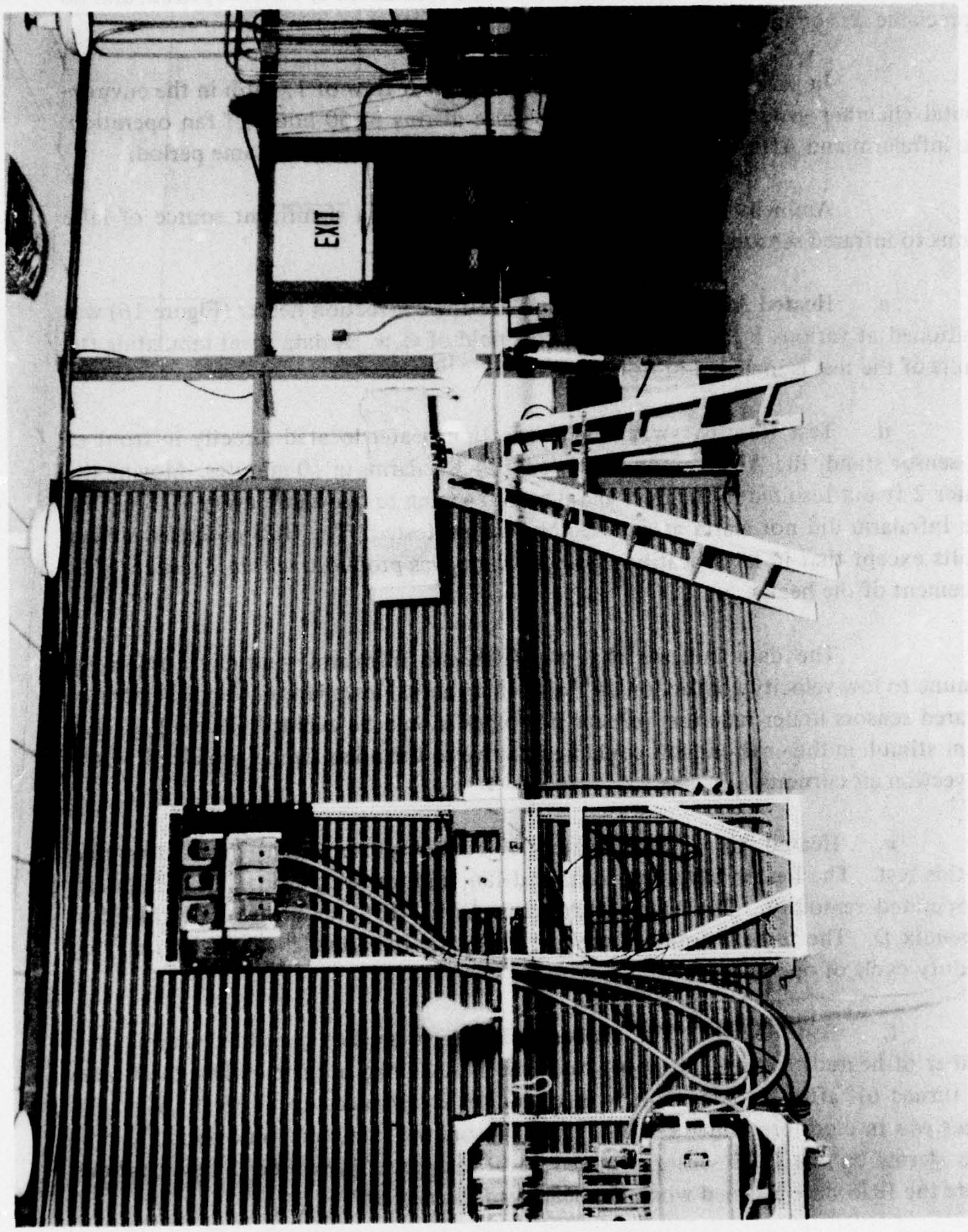


Figure 15. Testing sensors using a ducted fan.

b. **Test Results.** The IRIS, Infralarm, and ADL sensors did not alarm to this stimulus. The test was repeated using a tripod-mounted IRIS sensor head, and no appreciable sensor analog response was noted.

In paragraph 7b, it was noted that an air flow of 15 mi/h in the environmental chamber generated only five IRIS false alarms in 60 hours of fan operation. The infralarm and ADL sensors generated no false alarms during the same period.

Ambient air flow does not appear to be a significant source of false alarms to infrared sensors.

c. **Heated Air – Convection.** A 2250-W convection heater (Figure 16) was positioned at various locations in the sensors field of view. A data sheet tabulating the results of the test is included in Appendix D.

d. **Test Results.** With the convection heater located directly in front of the sensor stand, the ADL sensor generated 60 false alarms in 10 minutes. Moving the heater 2 ft out resulted in the false alarm rate dropping to one alarm every 10 minutes. The Infralarm did not alarm at any heater location tested. The IRIS produced similar results except that in two locations a single alarm was produced within 1 minute after placement of the heater.

The data indicate that the IRIS and Infralarm sensors are relatively immune to low-velocity convection air flow. In an actual installation, the placement of infrared sensors under radiators or near hot pipes should be avoided since other false-alarm stimuli in the environment could be additive to the noise signals produced by the convection air currents.

e. **Heated Air – Space Heater.** A 1650-W portable space heater was used for this test. The heater has a self-contained fan, and for test purposes the heater can be operated remotely. The heater is shown in Figure 17; a data sheet is included in Appendix D. The test consisted of moving the heater to various locations and varying the duty cycle of operation.

f. **Test Results.** The IRIS and Infralarm sensors generated alarms at a number of heater locations. In most cases the false alarms occurred when the heater was turned off after 7 to 25 seconds of operation at distances up to 35 ft. When the heater was in close proximity (15 ft) to the sensors the minimum time period to produce alarms on the IRIS sensor dropped to 3 seconds. There were a few locations where the IRIS false alarmed when the heater was turned on.

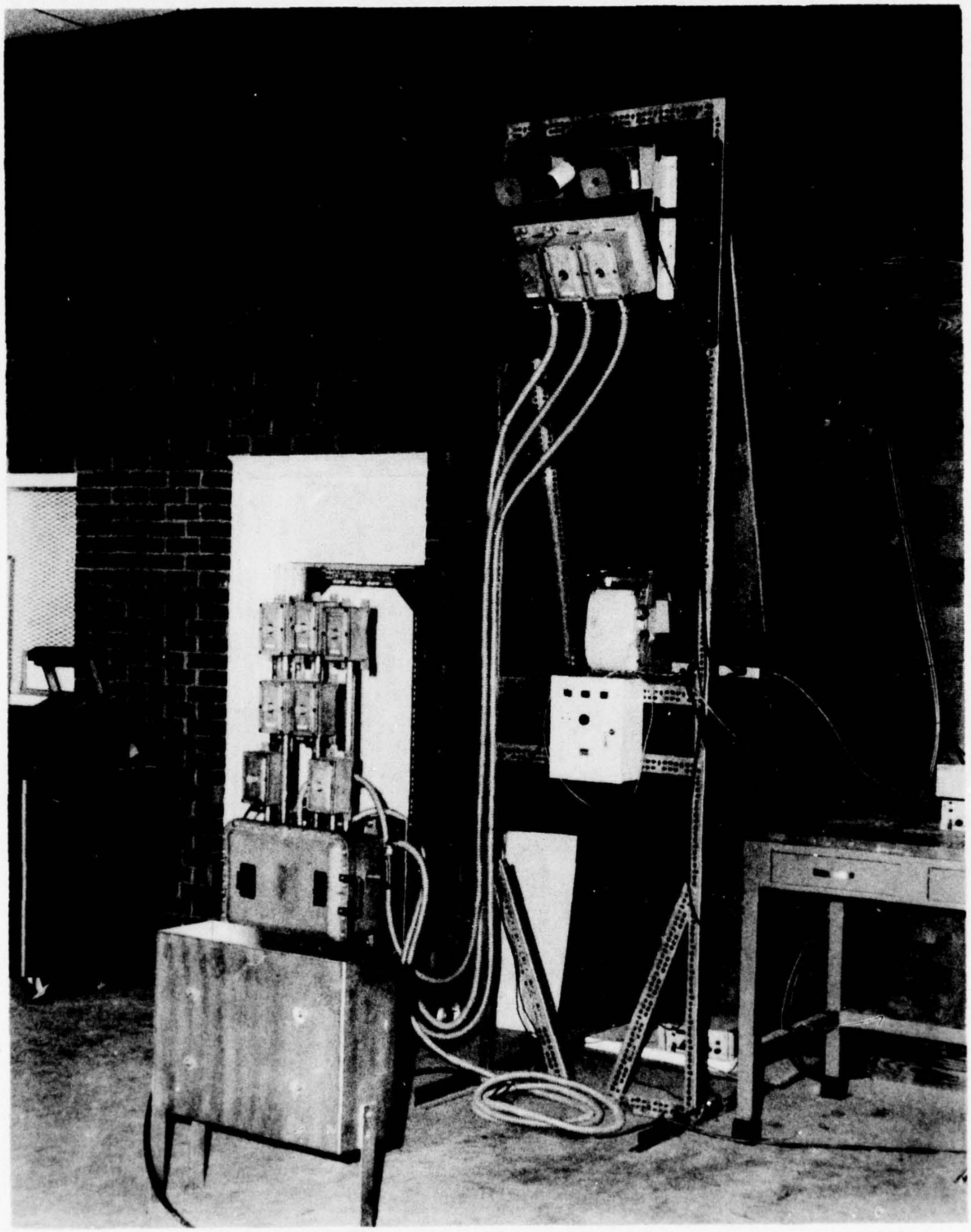


Figure 16. Testing sensors using a convection heater.

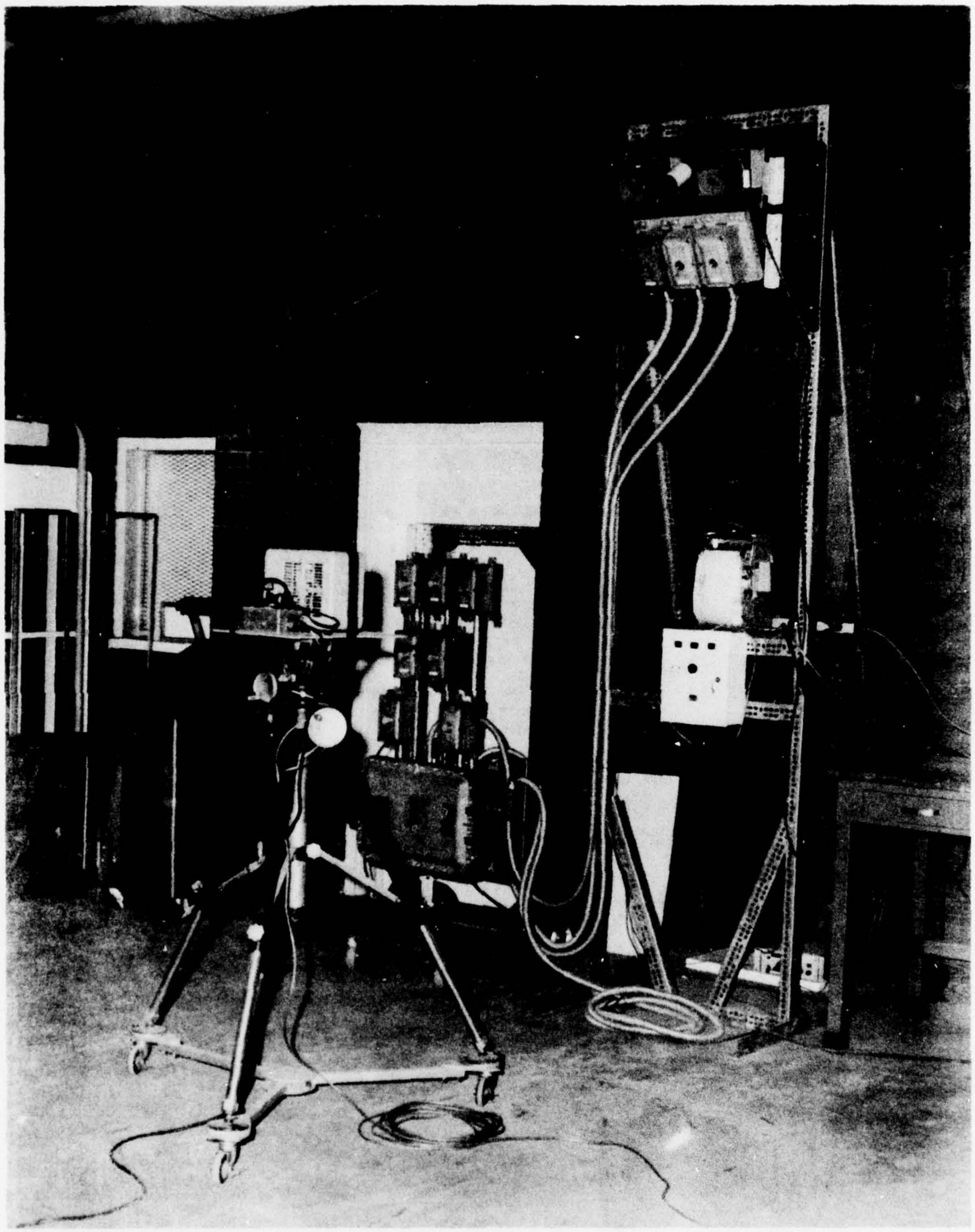


Figure 17. Testing sensors using a portable space heater.

The ADL sensor is a short-range sensor (approximately 20 ft of range) and did not alarm during this test for any heater location.

The IRIS sensor analog response to the space heater was recorded using a single sensor head mounted on a tripod. Figure 18 shows the resulting analog with the heater at a distance of 4 ft from the sensor. Test point 1 is the second stage of analog amplification; test point 5 is the third and final stage of analog amplification prior to level detection. As can be seen, when the heater is turned on the heated air produces analog just below the threshold level. Figure 19 shows the results of moving the heater to a range of 6 ft. Analog is now well above threshold limits. Test points 3 and 4 are level detector outputs representing positive and negative excursions exceeding the threshold limits (approximately ± 1.0 volt). Test point 17 is the sensor alarm output signal resulting when a positive and negative analog excursion exceeding the threshold limits occur within 20 seconds.

If the analog test point were used during the selection of sensor head locations, the effects of false alarm stimuli such as space heaters, hot pipes, etc., could be eliminated or significantly reduced.

g. **Heat Air – Convection and Forced-Air Currents in a Small Room**. The IRIS, Infralarm, and ADL sensors were installed in test location B (Figure 3). This is a small 12-ft by 15-ft windowless room with a centrally located, ceiling, forced-hot-air heating register. The sensors were mounted on the rear wall 6 feet from the register. A convection heater was used to maintain the room air temperature at approximately 120° F for 280 hours. Air turbulence was provided by the convection heater and the building heating plant.

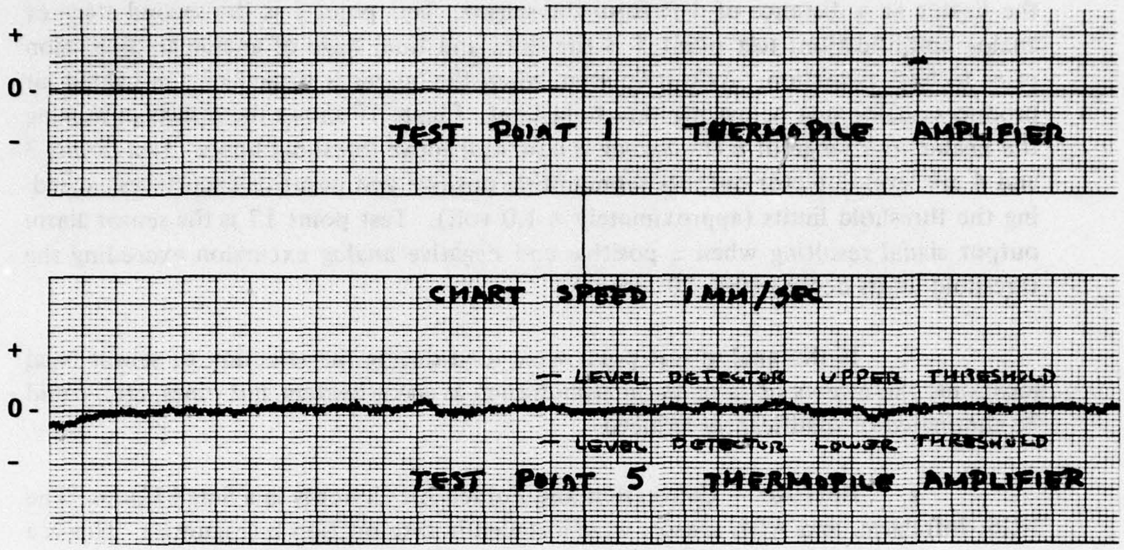
h. **Test Results.** During the 280-hour test period, the ADL sensor alarmed once at 2300 hours, October 8 and again at 0600 hours, October 9. The IRIS alarmed once at 0100 hours, October 11 and again at 1100 hours, October 15. There were no false alarms produced by either Infralarm sensor.

This was a small room (12 ft by 15 ft); therefore, it should be noted that each IRIS/Infralarm horizontal field of view (see Figure 2) is approximately 6 inches in the area of the register. The register is a horizontally diffusing type (12 in. by 12 in.); therefore, air is exhausting simultaneously into adjacent sectors. Simultaneous irradiation of the series opposing thermopiles as used in IRIS/Infralarm sensors theoretically produces a zero output voltage.

The fact that the IRIS false alarmed and the Infralarm did not, can be attributed to the fact that the IRIS sensor uses a thermally controlled gain circuit to increase the sensor sensitivity at higher temperatures and because a longer alarm

1. Portable heater (1650 watts) located 4 feet from sensor head. Air movement across sensor field of view.

2. Heater turned off.



3. Heater turned on.

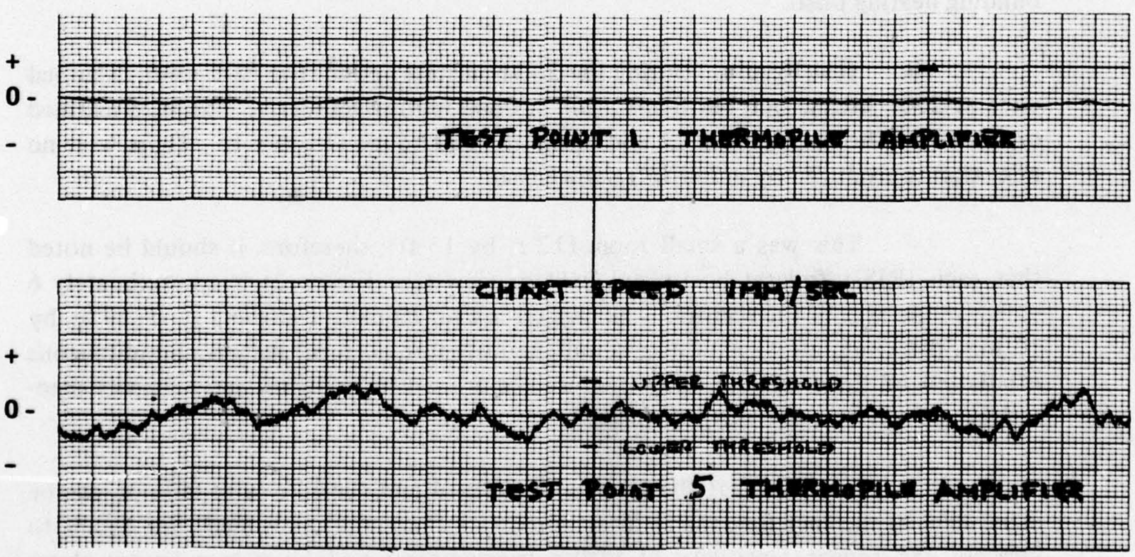


Figure 18. IRIS analog response to space heater at 4 ft.

1. Portable heater (1650 watt) located 6 feet from sensor head. Air movement across sensor field of view.

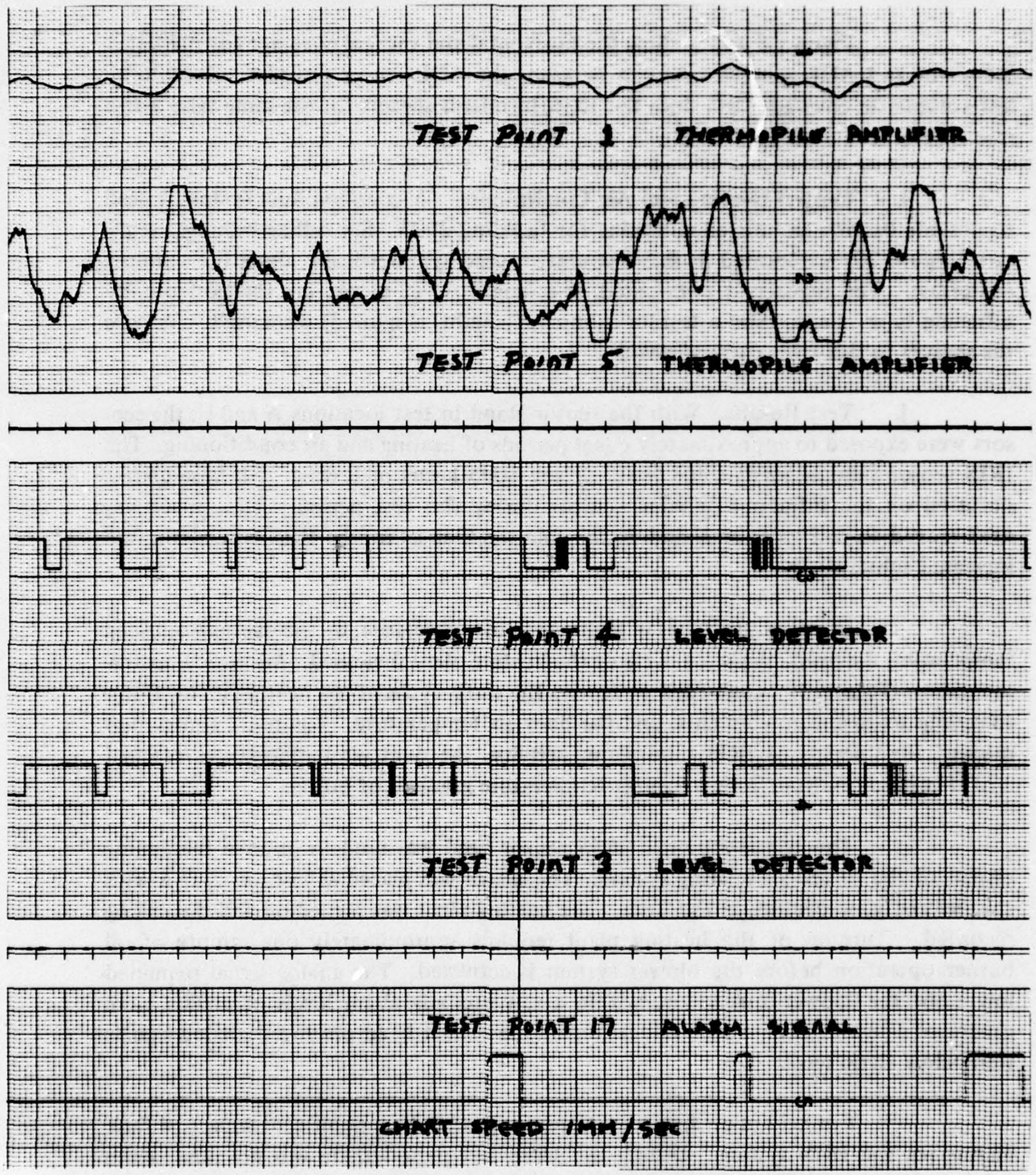


Figure 19. IRIS analog response to space heater at 6 ft.

window time is used by the IRIS (20 seconds for the IRIS versus 5 seconds for the Infralarm).

Figures 4 and 5 show the horizontal and vertical coverage for the IRIS/ Infralarm and ADL sensors. As can be seen, the ADL sensor provides substantially less volumetric coverage than does the IRIS/Infralarm sensors for the same false alarm rate experienced during this test.

i. **Central Heating and Air Conditioning.** A common duct system is used to provide heating and air conditioning for Building 2093. Six ceiling-mounted registers (Figure 20) are located in this test area, spaced symmetrically along the building centerline. The registers are mounted at a height of 12 ft and are the horizontally diffusing type. Sensor stand test locations A, C, and D (Figure 3) were used to expose the sensors to this false alarm stimulus.

j. **Test Results.** With the sensor stand in test locations A and C, the sensors were exposed to approximately equal periods of heating and air conditioning. The IRIS sensor false alarmed three times during 1095 hours of testing. No false alarms occurred on the Infralarm or ADL sensors during this test period. The sensor was next moved to test location D and, as the cold weather set in, the IRIS false alarm rate increased substantially.

Building 2093 has a high heat loss; therefore, as the average outdoor temperature dropped, the duty cycle of the heating plant increased. Additional instrumentation (Figure 21) was added to record the duty cycle of the heating plant, floor-to-ceiling temperature gradients, and the duct air temperature. Figure 22 shows that during the period of IRIS false alarm activity, the duct air temperatures reached 170° F with a resulting floor-to-ceiling temperature gradient of 60° F.

The tripod-mounted IRIS sensor head was used to observe the analog effects of the forced-air heating system. The sensor was placed at test location A with the field of view parallel to the floor. The heating plant was turned on and the analog recorded. Turn-on of the heating plant requires approximately one minute of oil burner operation before the blower system is activated. The analog signal remained low until the blower turned on; within a few seconds alarm levels of analog were generated (Figure 23). Slight relocation of the sensor head produced analog signals well below alarm level.

Forced-hot-air heating systems appear to be a significant source of false alarms for the IRIS system. During the same test period there was no false alarm generated by the Infralarm or ADL sensors.

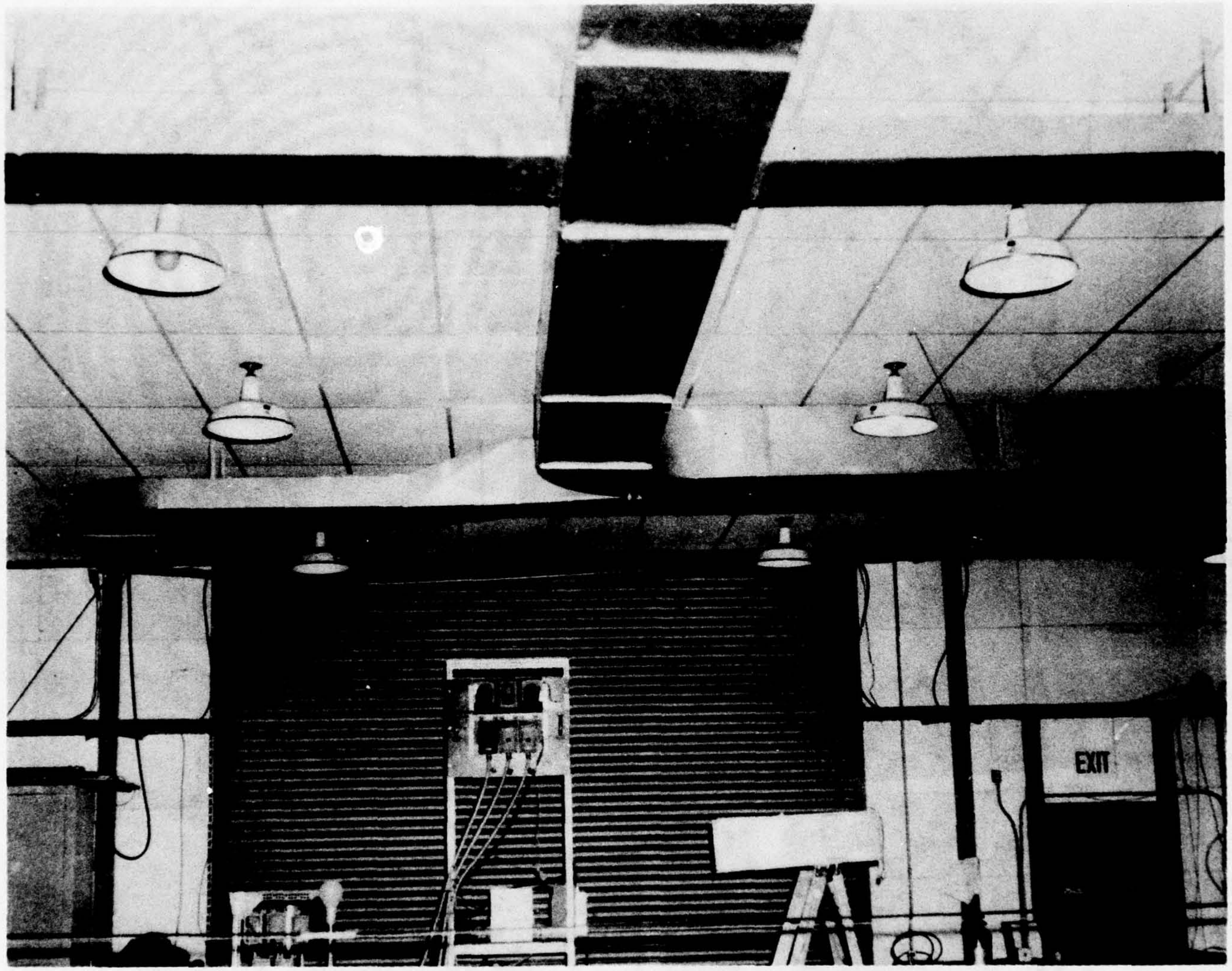


Figure 20. Building 2093 duct system.

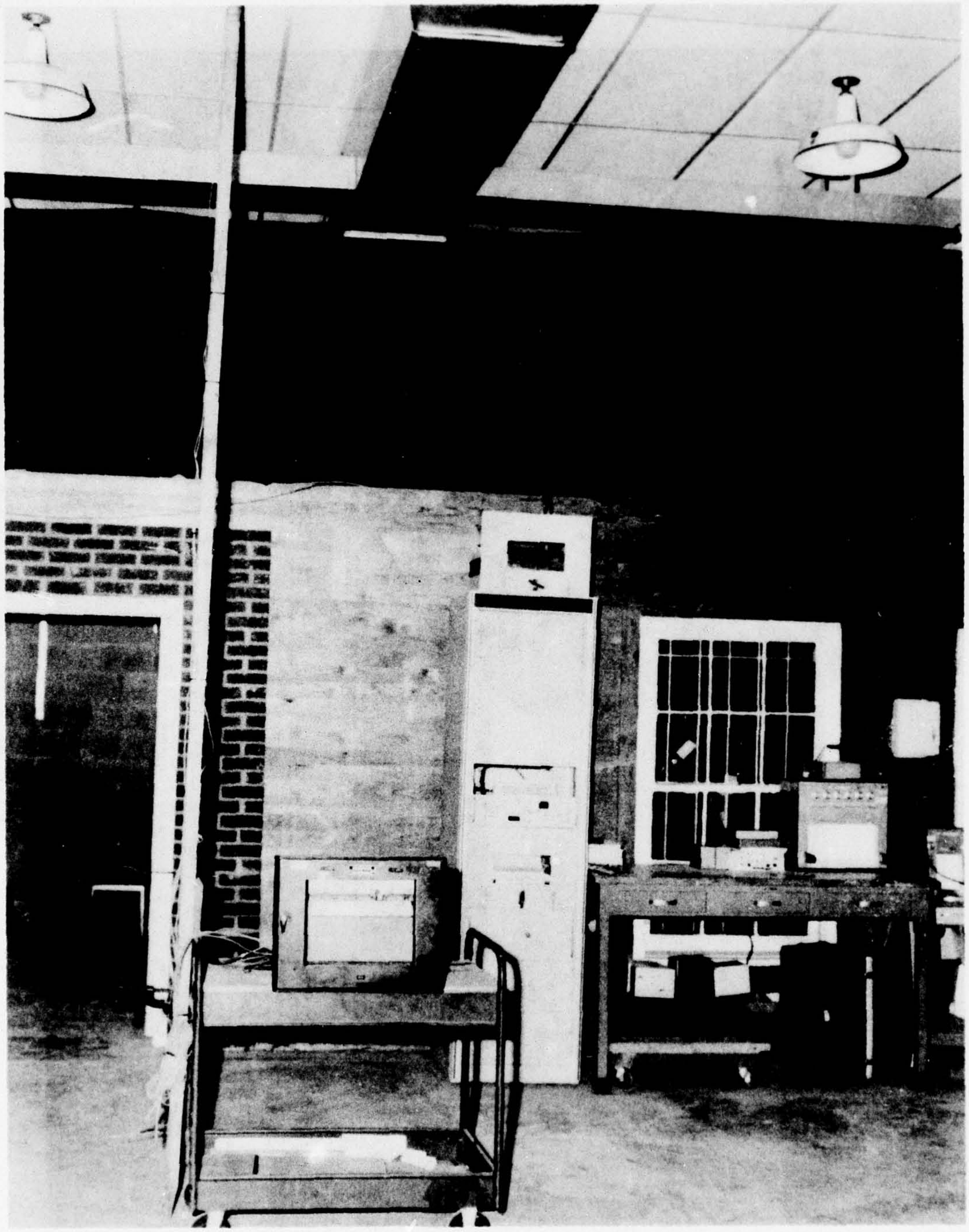
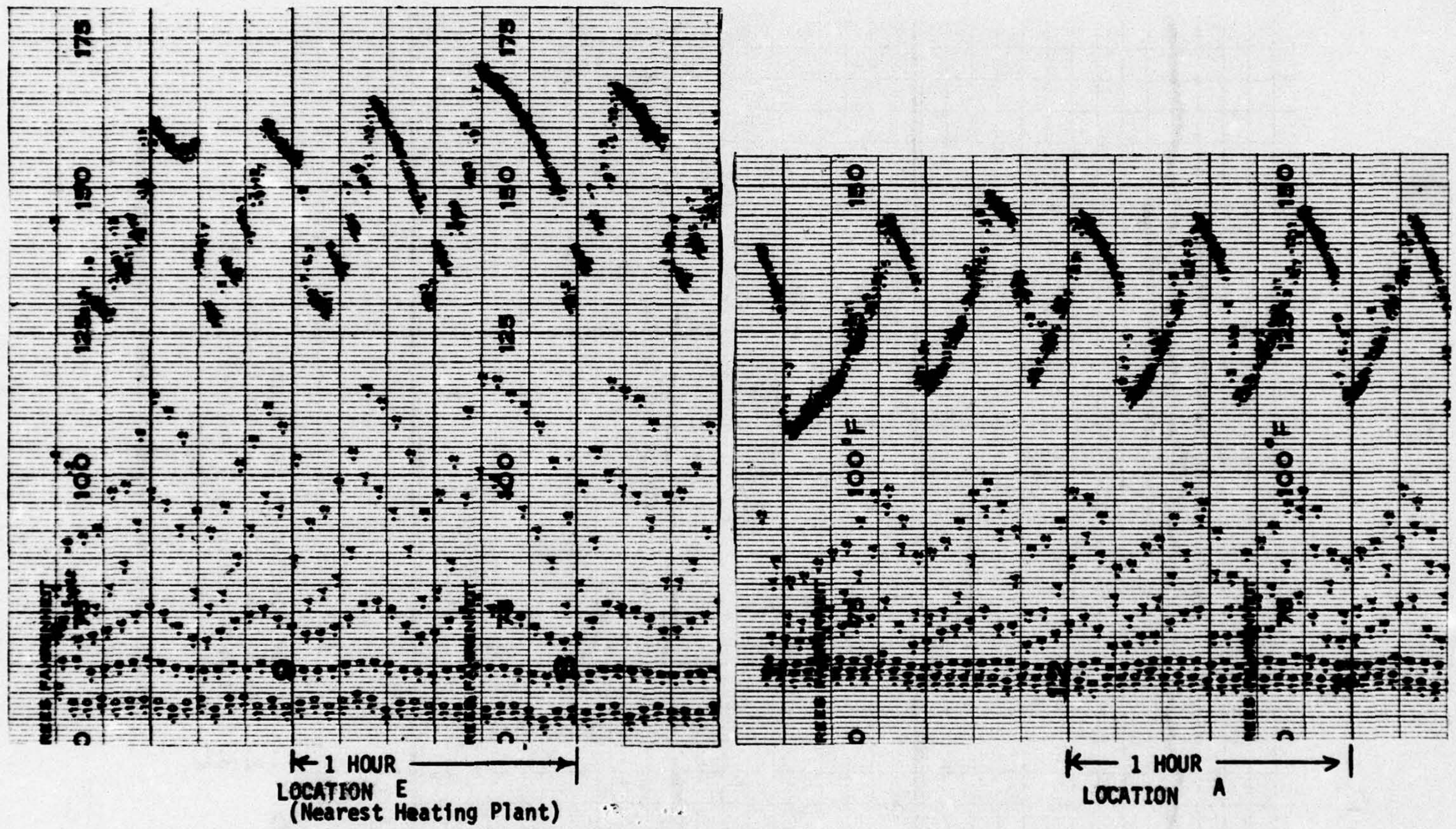


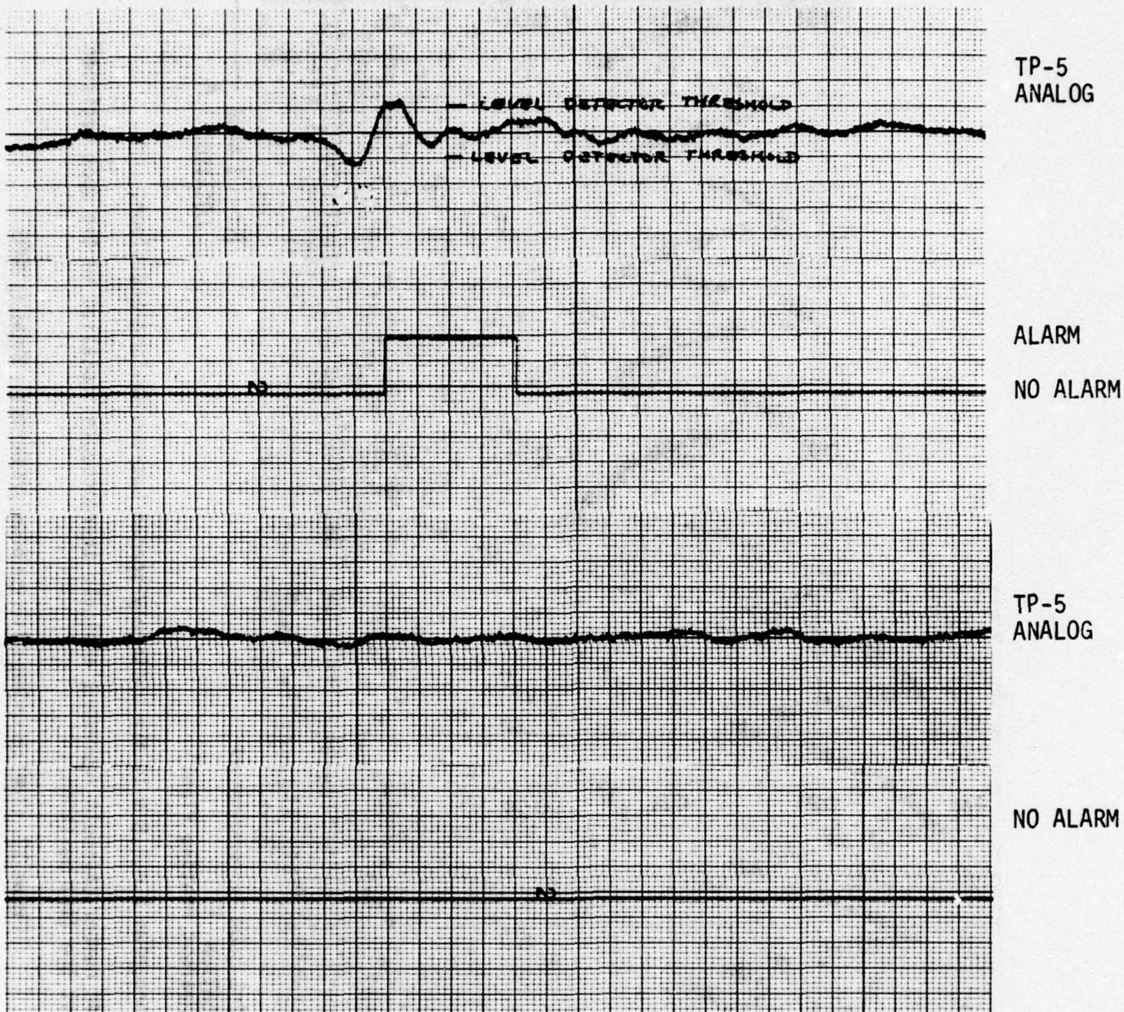
Figure 21. Temperature gradient test equipment.



NOTES: 1. Thermocouples 2,4,6,8 & 10 are uniformly spaced between ceiling and floor.

2. All odd number channels represent a single thermocouple installed in the duct register nearest the test position.

Figure 22. Chart recording of temperature gradients for Building 2093.



NOTES:
1. Sensor located in Position A
2. Analog sensitivity .2 volts/div.
3. Alarm sensitivity 1 volt/div.
4. Chart speed 1 mm/second.

Figure 23. IRIS analog response to forced hot air heating system.

Air conditioning does not appear to be a source of false alarms for these sensors if reasonable precautions are used in the location of the sensors. Of the three false alarms generated in 1095 hours of testing, two occurred in the early morning hours and the third occurred after the air conditioner was turned off for the season.

9. **Electromagnetic Interference Susceptibility Test.** Melpar Division of E-Systems Incorporated, Falls Church, Virginia, performed the EMI evaluation on the infrared sensors at the MERADCOM test facility (Building 2093).

a. **General.** The test procedures of Military Standard MIL-STD-461A, Notice 4 (Army) were used as guidelines for this evaluation. Four separate susceptibility tests were performed:

Method CS01 – Power line conducted susceptibility, 30 Hz to 50 kHz at levels of 1 and 3 V rms.

Method CS02 – Power line conducted susceptibility, 50 kHz to 400 MHz at a level of 1 V rms.

Method CS06 – Power line spike susceptibility to random and synchronized ± 100 V spikes.

Method RS03 – Radiated electric field susceptibility from 14 kHz to 10 GHz at field strengths of 5 V per meter and greater (Figures 24, 25 and 26).

In this test, the IRIS, Infralarm, and ADL sensor electronics packages were exposed to the interference stimuli to determine the false alarm susceptibility. In addition, an intruder walked through the field of view of each sensor to verify that each sensor still retained the ability to detect.

The IRIS was supplied with an accessory unit, called the Tell Tale, which interfaced with the control unit, to identify with a latching LED indicator the sensor head responsible for the control unit alarm. The Tell Tale was initially used in the testing for this purpose; however, during some preliminary EMI radiation tests the IRIS generated false alarms at low RF levels. The Tell Tale consistently indicated all sensor heads had produced the control unit alarm. The Tell Tale was removed because it apparently increased the IRIS EMI susceptibility and was not intended to be used in a normal IRIS installation.

b. **Test Results.** With the Tell Tale removed, the IRIS, Infralarm, and ADL sensors successfully passed all the required tests. Procedures and test data sheets are included in Appendix F.

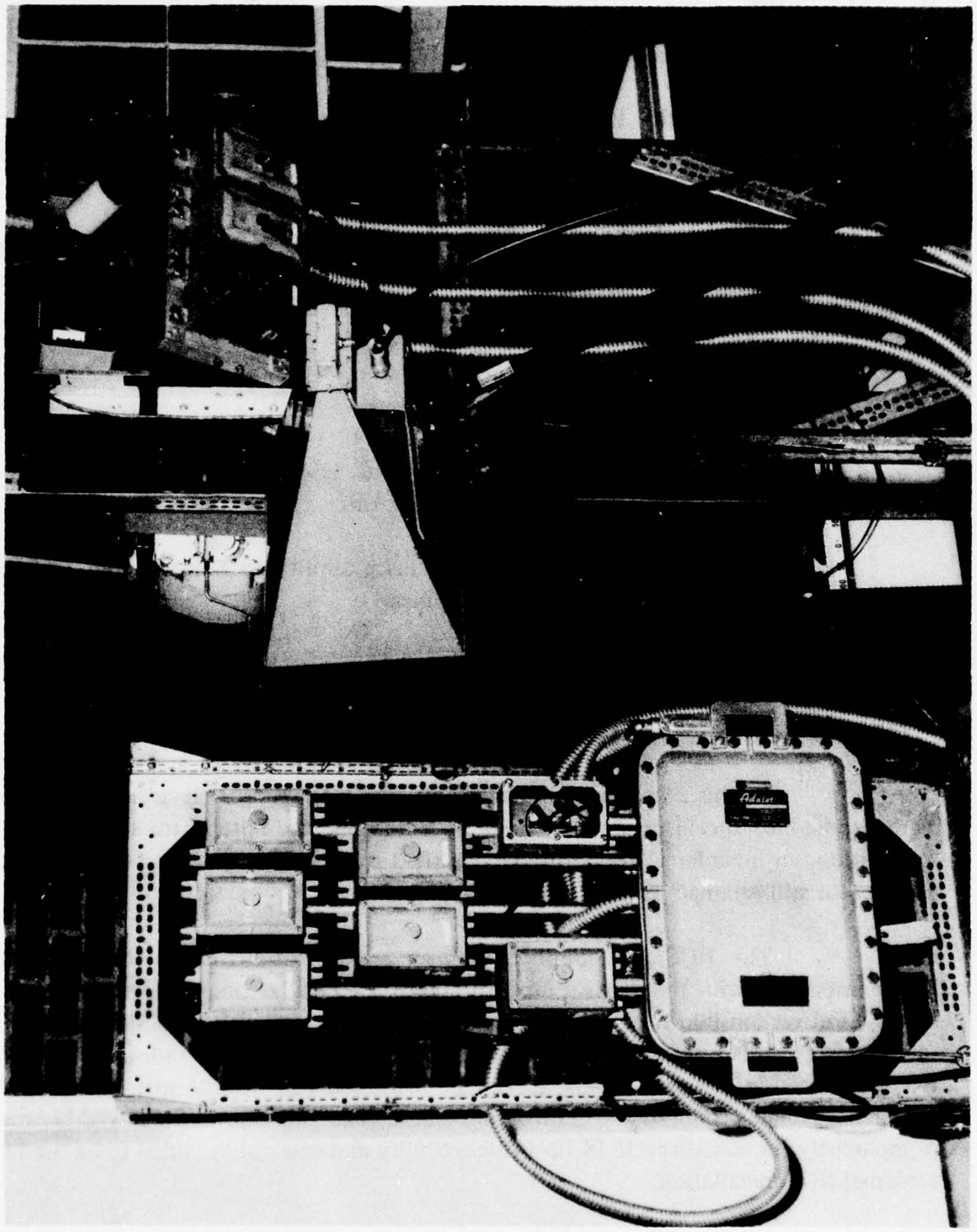


Figure 24. Sensor orientation during high-frequency EMI testing.

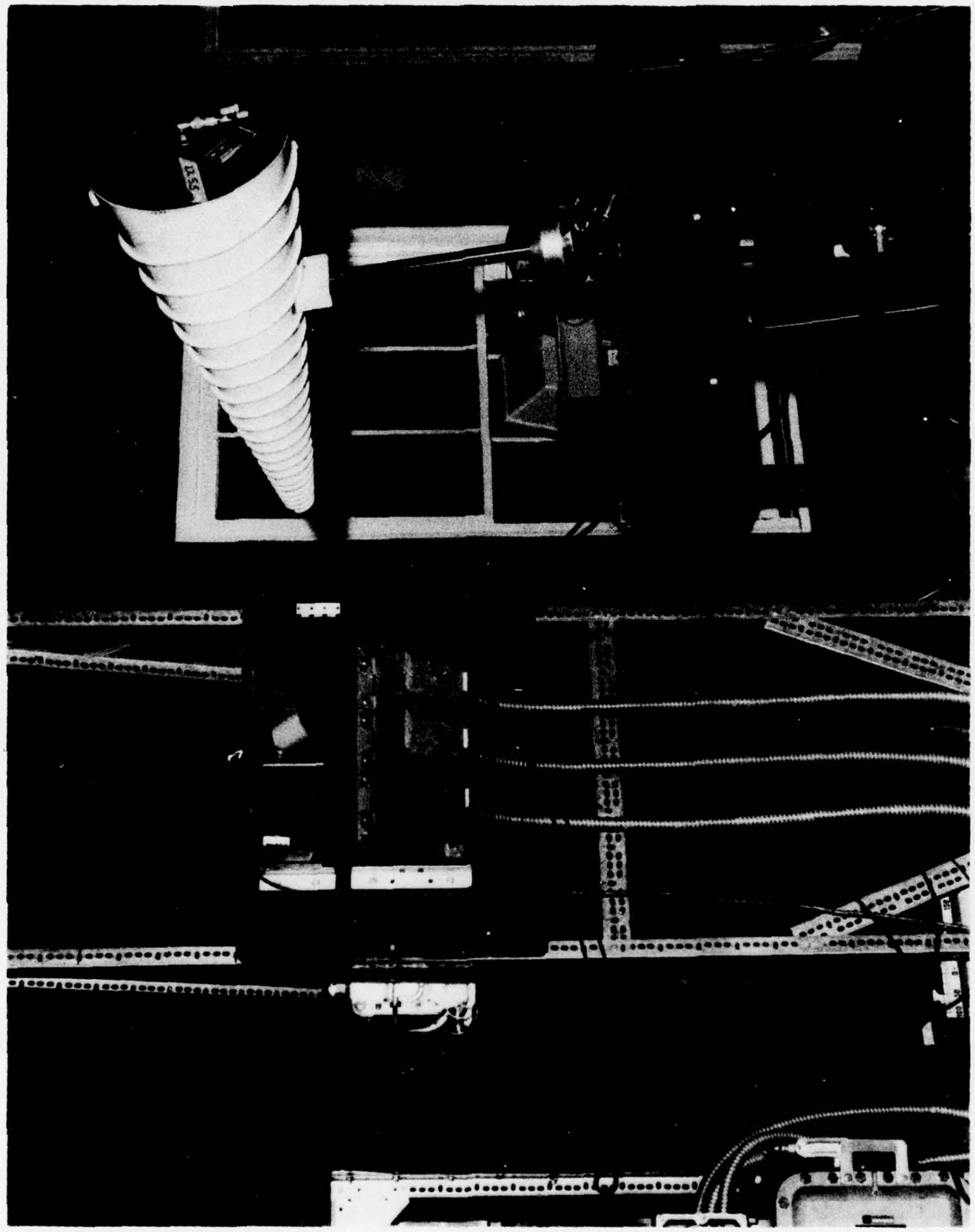


Figure 25. Sensor orientation during medium-frequency EMI testing.

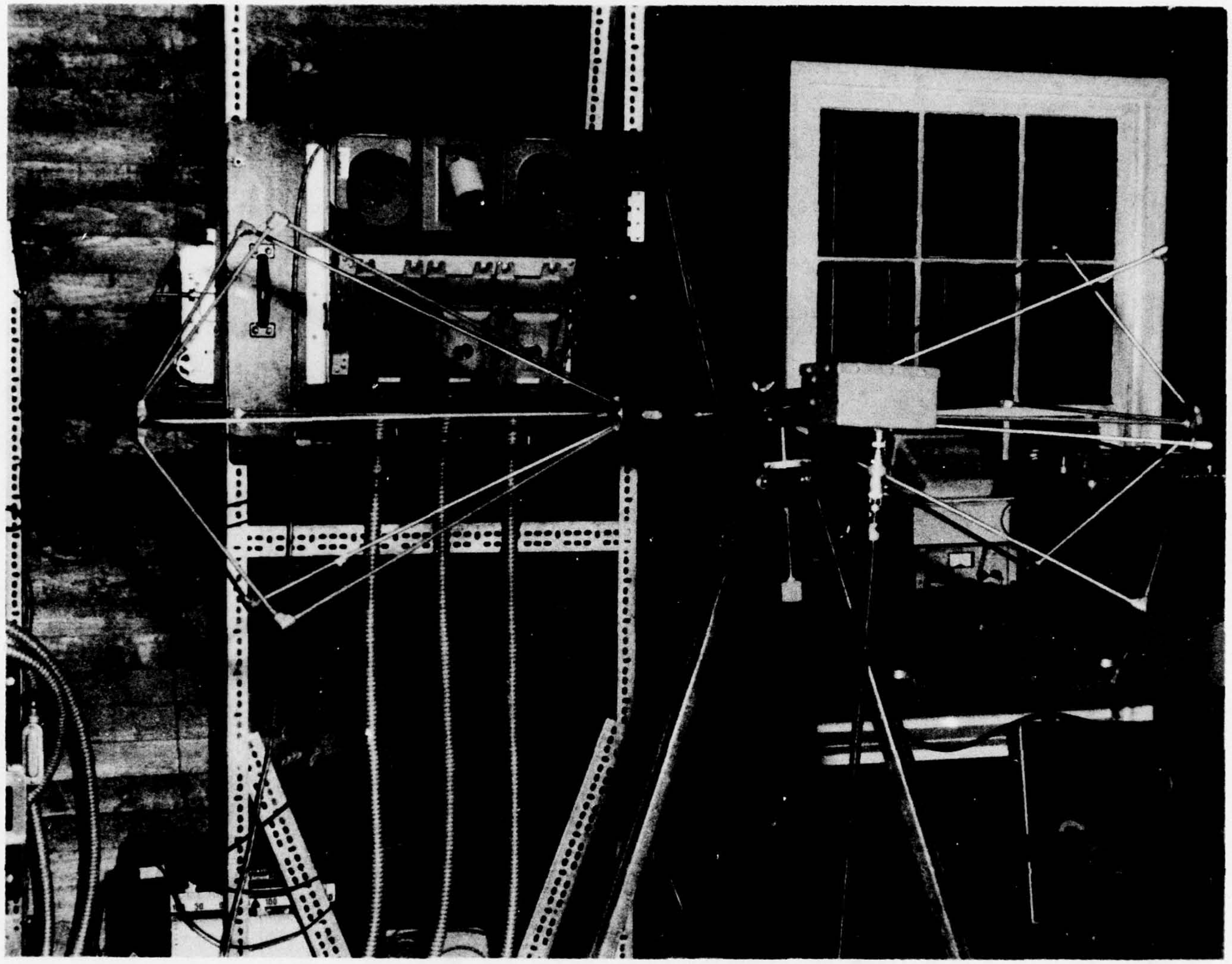


Figure 26. Sensor orientation during low-frequency EMI testing.

c. **Hazards.** High-voltage transients such as lightning can severely affect the reliability and false alarm performance of sensor systems. Worldwide fielding of the Joint Services Interior Intrusion Detection System (J-SIIDS) has revealed that in some areas, elaborate protection networks must be used to prevent the lightning electromagnetic pulse from entering the enclosures and causing failures or false alarms. The lightning pulse can easily enter the IRIS control unit enclosure by way of the alarm and tamper line outputs. The IRIS has RF filtering on the a.c. power line but may be inadequate for lightning-induced power line transients.

A MERADCOM contractor specializing in the protection of electronic equipment from lightning and transient effects has recommended that adequate protection networks be used at all points of entry. The equipment should be able to withstand without failure or upset a direct discharge of a 0.1-microfarad capacitor, charged to at least 10 kV, into all points of entry. The IRIS sensor does not have any protection for the C-MOS circuitry at the sensor head output or the control unit input and would surely fail the above test.

Another hazard often presented to electronic equipment is an individual with a large static charge on his body who comes in contact with sensitive circuitry during the installation or operation of the equipment. Static electrification of an individual may reach 10,000 V with a peak discharge current of 100 A. In areas where static electrification is a problem, extreme care should be exercised in the installation and wiring of the IRIS system. In addition, operating personnel coming in contact with the enclosure, test lamp, or test switch may cause failures or faulty operation of the self-test and line supervision circuitry.

10. **False Alarm Monitoring Tests.** A strip chart event recorder was used to continuously monitor the IRIS, Infralarm, and ADL sensors for false alarms. During the time that Building 2093 was occupied, the recorder remained in operation to verify sensor detection capability.

a. **General.** Six test locations were used in order to expose the sensors to as much of the building environment as possible. These test locations, designated A through F, are shown in Figure 3.

b. **Test Results.** The following false alarms were recorded (a detailed false-alarm log is included in Appendix E):

Test Location	Hours	Number of False Alarms IRIS	Infralarm	ADL
A	316	0	0	0
A	682	2	0	0
B	280	2	0	2
C	97	1	0	0
D	122	Note 1	0	0
D	968	2	0	0
E	150	Note 2	0	0
F	130	0	0	8

Note 1 – Over a 4½-hour period, the IRIS false alarmed every 7.5 minutes.
Note 2 – IRIS sensor generated many false alarms because of heating plant operation during extremely cold weather.

(1) Location A. The IRIS sensor generated two false alarms during 998 hours of false alarm monitoring. The first alarm occurred at 0400 hours 27 August, and the second, at 0530 hours 4 September. The Infralarm and ADL sensors did not false alarm during this 998-hour test.

(2) Location B. The IRIS and ADL sensors each generated two false alarms in a small room maintained at +120° F. The IRIS alarmed once at 0100 hours 11 October and again at 1100 hours 15 October. The ADL alarmed once at 2300 hours 8 October and again at 0600 hours 9 October. The Infralarm sensors did not false alarm during this 280-hour test.

(3) Location C. A single IRIS false alarm occurred at 1600 hours 31 October. The Infralarm and ADL sensors did not false alarm during this 97-hour test period.

(4) Location D. During 122 hours of false alarm monitoring, the IRIS generated a number of false alarms between 0300 and 0730 hours 8 November. The alarms occurred every 7.5 minutes. Over an additional 968 hours, the IRIS sensor generated two false alarms. The Infralarm and ADL sensors did not false alarm during this test period.

(5) Location E. With the sensor stand facing the heating plant, the IRIS generated many false alarms. A slight repositioning of the sensor stand reduced the false alarm rate to zero over the same period. During the 150-hour test, no false alarms occurred on the Infralarm or ADL sensors. (It should be noted that it is poor practice to locate sensors with a large source of heat in the field of view.)

(6) **Location F.** The sensor stand was oriented to view the roll-up garage door at a range of 6 ft. Over a test period of 130 hours, the ADL sensor false alarmed 8 times because of wind-induced door movement. The IRIS and Infralarm sensors did not false alarm to this stimulus.

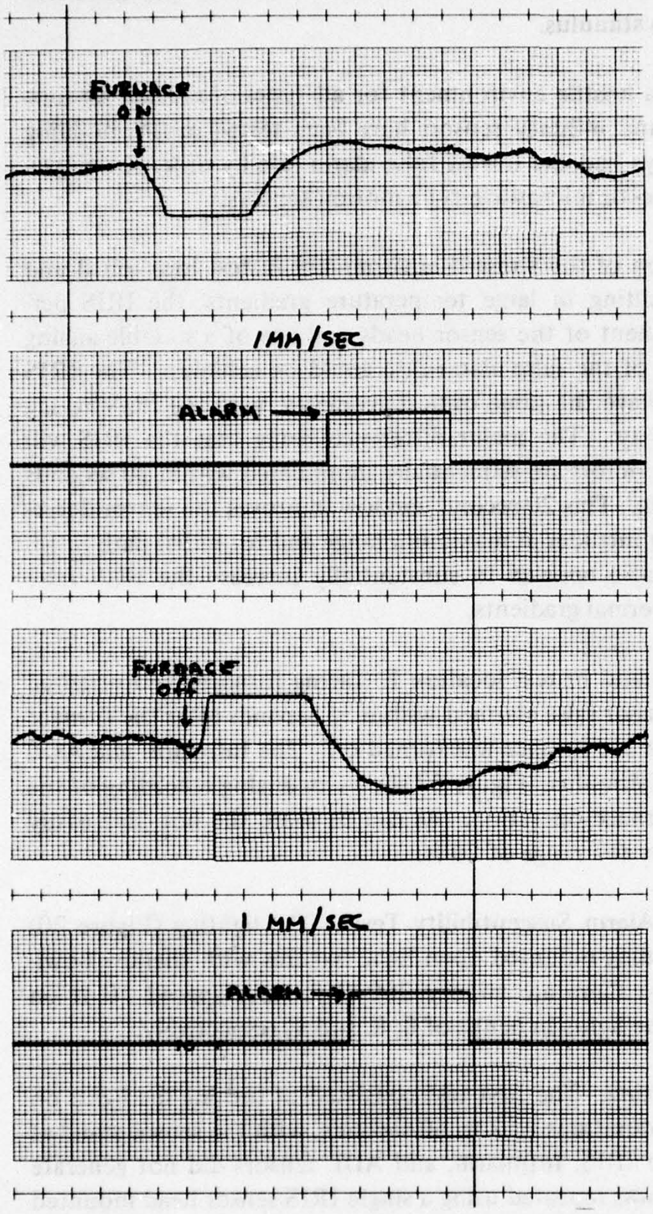
Building 2093 is a hostile environment for all types of motion sensors. Historically, many commercial and military sensors have been tested in this building and the infrared sensor has always had the lowest false alarm rate by orders of magnitude when compared to ultrasonic- or microwave-type motion sensors.

With the exception of the stressed environment in test location B and the unusually cold weather resulting in large temperature gradients, the IRIS performed well. With proper placement of the sensor heads and use of a suitable analog test point, substantial reduction of the false alarm rate could be achieved. The IRIS and Infralarm sensors appear to have the same optical geometry, with the IRIS having a slight edge on thermal sensitivity. The major difference being that the IRIS will generate an alarm when alternate sectors are sequentially illuminated within 20 seconds versus 5 seconds for the Infralarm. This 20-second window improves the sensor detection capability for a slow-moving intruder at maximum range and for radial path intrusions. The 20-second window also appears to substantially increase the IRIS false alarm rate in an area with large thermal gradients.

With the sensor stand in test location E (facing furnace) and oriented to view the flue pipe, the IRIS sensor false alarmed within 15 seconds after the furnace was turned on or 15 seconds after the furnace was turned off. The Infralarm and ADL sensors were not affected by this stimulus. Figure 27 shows an analog recording of the IRIS sensor head response to furnace operation. As can be seen, the hot pipe easily saturates the thermopile amplifiers at a range of 20 ft.

11. **Infrared Sensor False Alarm Susceptibility Tests.** The lighting (Figure 20) for Building 2093 consists of ceiling-mounted open light fixtures with shallow bowl-type reflectors. In the test area there are twenty 200-W fixtures spaced 10 ft on centers. Three switches control the lights in banks of 8, 8, and 4, respectively.

a. **Incandescent Lighting.** The first test consisted of turning the lights on and off in various sequences for durations of 2 to 60 seconds, with the sensor stand at test locations A, C, and D. The IRIS, Infralarm, and ADL sensors did not generate an alarm for this test. This test was repeated using a single IRIS sensor head mounted on a tripod and monitored for analog. The resulting analog was well below the alarm threshold level.



NOTES

1. Sensor head on tripod 20 feet from furnace.
2. Furnace turned on for five minutes; duct fan activated approximately one minute after oil burner starts.

Figure 27. IRIS analog response to furnace.

The test was further expanded to use a single light bulb on a rope-and-pulley arrangement (Figure 28) whereby a light bulb, mounted on a moveable platform, could be placed in different portions of the sensor field of view. The moveable platform was suspended 5 ft above the floor and 15 ft from the sensor stand. The platform direction of travel was perpendicular to the sensor field of view.

b. **Test Results.** A single light bulb in the sensor field of view and in close proximity to the sensor can cause false alarms when the light is turned on or off for periods of between 5 and 10 seconds for the IRIS and between 4 and 8 seconds for the Infralarm sensors. Figure 29 shows the resulting analog using the tripod-mounted IRIS sensor head at distances of 5 and 10 ft from the light bulb. The upper analog recording shows the light bulb being turned on and, 65 seconds later, turned off. The light was next moved to a distance of 10 ft, resulting in a substantial reduction in the analog signal. No alarms resulted from the first test even though the threshold level was exceeded due to the positive and negative excursions occurring in excess of 20 seconds. The lower analog recording shows the first test repeated, except the light was turned off after 10 seconds. Eight seconds after the light was turned off, the sensor head generated an output alarm signal. There were few locations where the turn-on or -off of the light for durations greater than 10 seconds produced an alarm from the IRIS or Infralarm sensors. It was not possible to generate an alarm on the ADL sensor using this technique.

The incandescent light does not appear to present any significant source of false alarms when the light has been on or off for more than 30 seconds and is located at distances greater than 15 ft. Momentary power interruptions would be the most likely source for this type of false alarm. Glass enclosures similar to that used on exterior lights could be used to reduce the rate of temperature change for lights in close proximity to the sensor.

The incandescent light poses some false alarm problems if the light fixture is capable of even small displacements due to building vibration from storms, aircraft, etc. To test for this effect, the light bulb was turned on for an extended period of time to stabilize its temperature. The moveable platform was then given slight displacements in the sensor field of view, resulting in alarms from the IRIS, Infralarm, and ADL sensors for platform displacement of less than ¾ inch. Other locations across the field of view produced similar results. For metal structures with suspended lighting, this could be a significant source of false alarms.

c. **Fluorescent Lighting.** A standard 48-inch, twin 40-W fluorescent lighting fixture was used as the stimulus for this test. The light was placed in various locations in the sensor field of view and turned on and off for duty cycles from 2 to 60 seconds.

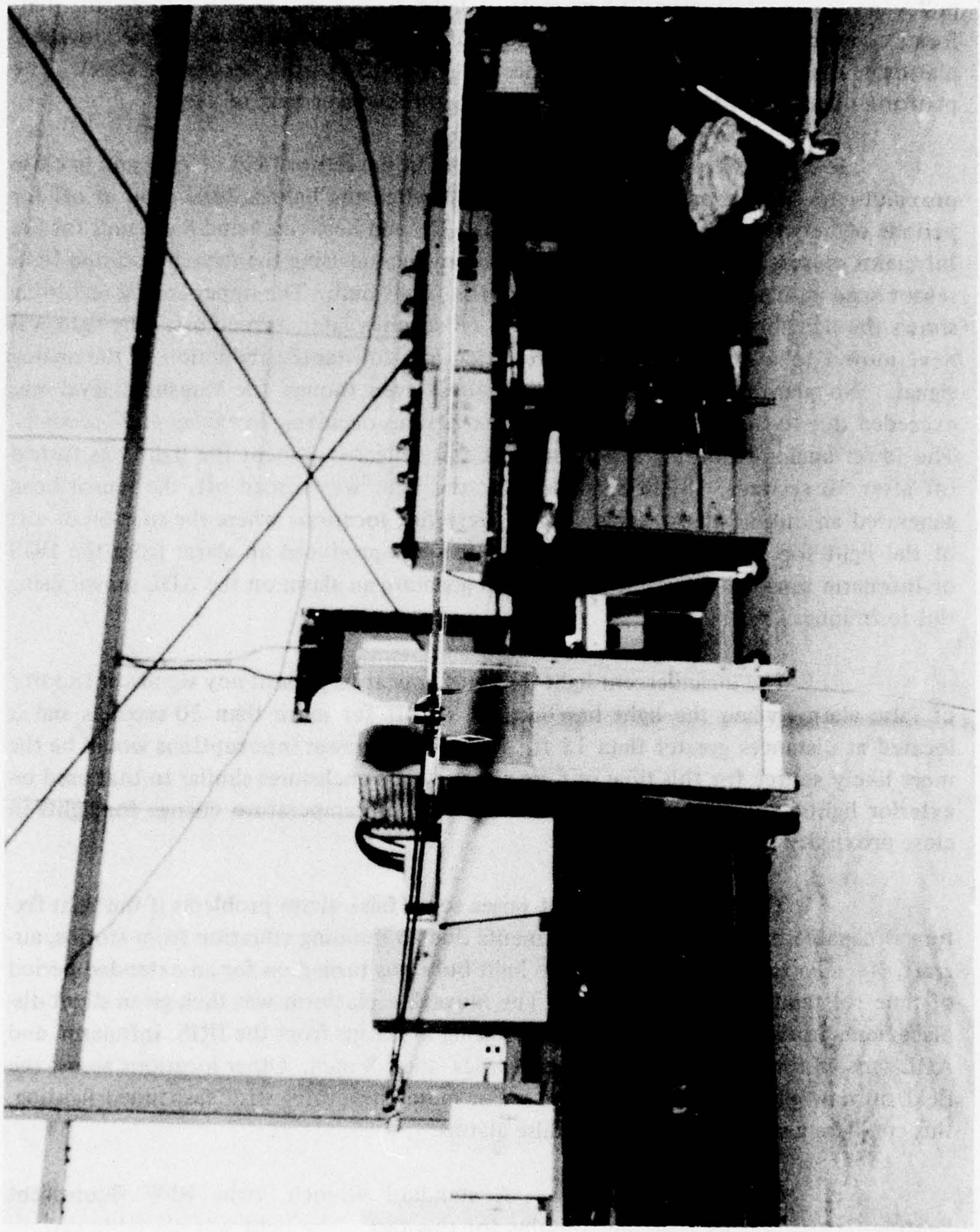
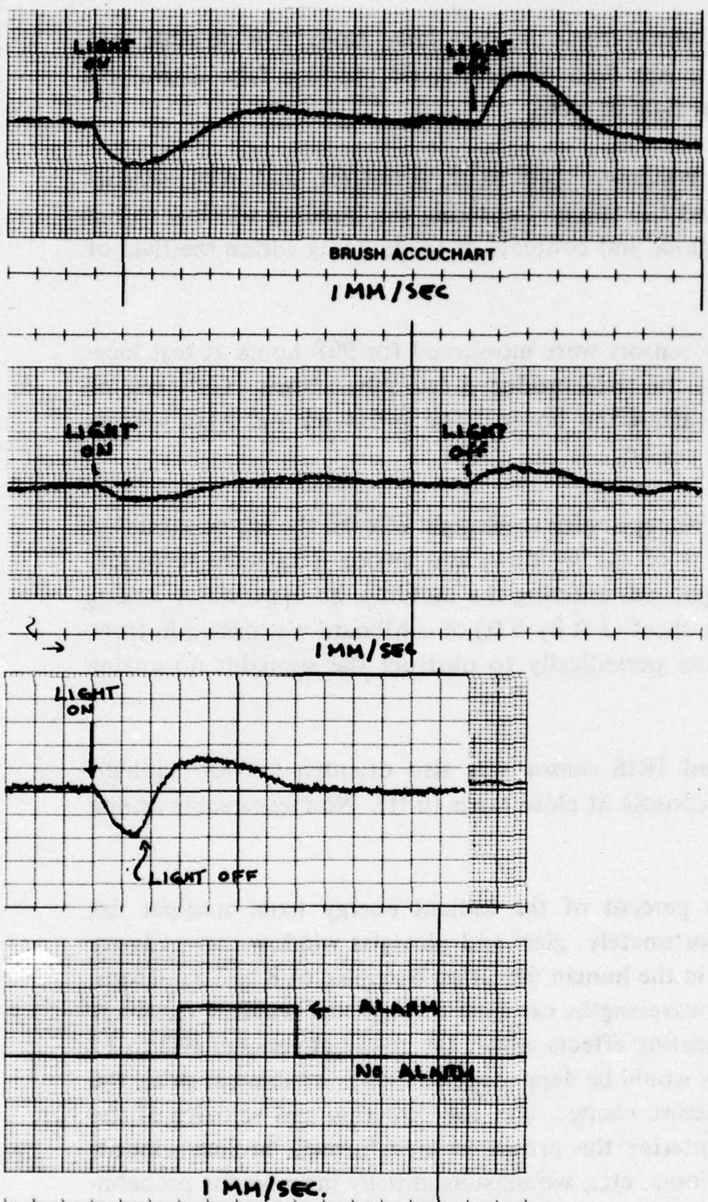


Figure 28. Moveable platform test fixture.



Turn on and off of 200 watt light 5 feet from sensor.
NO ALARM

Turn on and off of 200 watt light 10 feet from sensor.
NO ALARM

Turn on and off of 200 watt light 5 feet from sensor.
ALARM

NOTES

1. Chart speed 1mm/second.
2. Sensitivity .2 volt/per minor division.
3. Analog taken at test point 5 referenced to test point 9.

Figure 29. IRIS analog response to incandescent light.

d. **Test Results.** The IRIS, Infralarm, and ADL sensor did not alarm to this stimulus. The tripod-mounted IRIS sensor head was also subjected to this test, resulting in no appreciable increase in the sensor analog level.

Since fluorescent light fixtures are such large items, it is possible that suspended units swaying in the sensor field of view could produce false alarms by momentarily obstructing the sensor field of view.

e. **Sunlight Entering Window.** The IRIS, Infralarm, and ADL sensors were placed in test locations A and C. Sunlight entering the building window in the late afternoon is incident on the floor and contents of the building within the field of view for all three sensors.

f. **Test Results.** The sensors were monitored for 998 hours at test locations A and C, during which time the IRIS produced two false alarms. Only one of these alarms occurred during the afternoon hours. The Infralarm and ADL sensors did not false alarm during this test period.

To test further for susceptibility to sunlight effects, the tripod-mounted IRIS head was placed within 6 ft of the window, and analog data were recorded. Throughout the period the sunlight was entering the building, no appreciable analog was measured. In addition, a large sheet (3 ft by 6 ft) of cardboard was passed in front of the exterior side of the window periodically to obstruct the sunlight; no analog response was noted.

The tripod-mounted IRIS sensor was also oriented to view sunlight reflections off a large electronics console at close range (6 ft). No measureable analog resulted from this test.

Approximately 98 percent of the radiant energy from sunlight lies between 0.15 and 3 microns. Fortunately, glass and plexiglas window materials are effective filters for infrared energy in the human detection bandpass of 8 to 14 microns. However, sunlight at the shorter wavelengths can pass through the window relatively unattenuated and produce local heating effects which can re-radiate energy at 8 to 14 microns. The effect on the sensor would be dependent on many variables; such as, the surface-irradiated, rate of temperature change, and the direction and velocity of the moving heat pattern. Sunlight entering the protected area through broken window panes, ventilators, poorly fitting doors, etc., would substantially increase the probability of false alarms due to direct or reflected sunlight incident on the sensors.

g. **Insects.** The test was performed by using a small (approximately ¼-in.) randomly shaped piece of blackened plastic to simulate an insect. This target, sus-

pended by a thread, was then moved in close proximity to the sensor optics in a manner similar to a flying insect about to land.

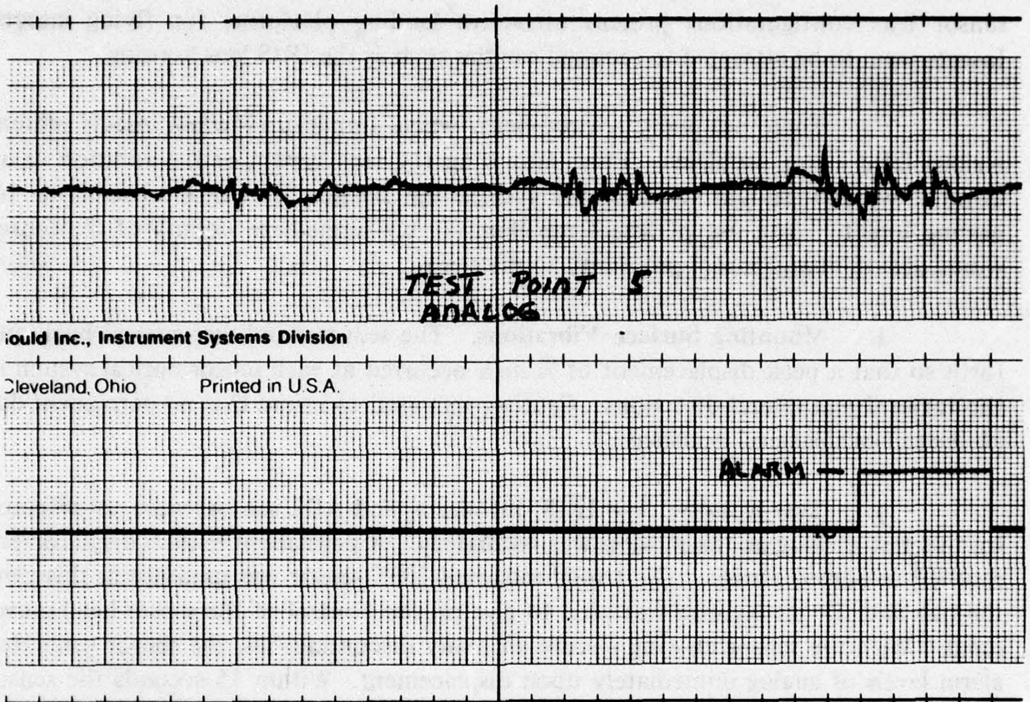
h. Test Results. The IRIS, Infralarm, and ADL sensors readily alarmed to this stimulus when the target was within 1 or 2 inches of the sensor optics. The test was repeated using the tripod-mounted IRIS sensor head; a sample analog recording of this stimulus is shown in Figure 30. The IRIS, ADL, and, to a lesser degree, Infralarm sensor lens configurations present attractive landing platforms for flying insects. Insects seem to be attracted to recessed cavities such as the IRIS lens housing.

There are many environments where flying or crawling insects present serious false alarm problems. Flush-mounting the lens system or the addition of an infrared window should considerably reduce the possibility of lens obstruction by nesting insects. The use of insect repellents in the immediate vicinity of the sensor would also minimize insect proximity to the sensor.

i. Mounting Surface Vibrations. The sensor stand was rocked back and forth so that a peak displacement of ½ inch occurred at each sensor optical system in the forward and lateral directions. Caution was used to insure that no permanent displacement of the stand occurred.

j. Test Results. The IRIS, Infralarm, and ADL sensors were not affected by this test as long as the motion was oscillatory. A permanent ½-inch displacement resulted in sensor alarms. The tripod-mounted IRIS sensor was used again; this time the pan and tilt mechanism was used to give precise control of the sensor head movement. With the sensor viewing a scene of many discontinuities, the sensor generated alarm levels of analog immediately upon displacement. Within 15 seconds the sensor head produced the output alarm signal. When the sensor head was repositioned to view a uniform scene, in this case the ceiling tile, the same movement of the sensor head generated low levels of analog. The angular movement was the same in both tests, approximately 2 degrees. Reasonable levels of wall vibration (less than 1/8-inch peak displacements) do not in most cases present a false-alarm problem for these sensors; however, critically located items in the sensor scene could result in a false alarm if the vibration caused a significant thermal change in the sensor scene.

In sheet metal buildings, the walls can easily be displaced 1/8 inch or greater by external forces. Most sheet metal buildings use widely spaced structural frames to which the sheet metal wall panels are attached. To provide the detection coverage required, it may be necessary to mount the sensor on these sheet metal panels. In some instances residual stresses due to the expansion and contraction of the structure could produce the "oil can" effect on these wall surfaces. Reinforcement of these panels or the addition of suitable braces should minimize sensor movement.



TEST CONDITIONS:

1. Single detector mounted on tripod with field of view facing uniform background.

2. Blackened target of non-symmetrical configuration with a maximum dimension of .25" was suspended by a thread and passed through the detector field of view. The sensor alarmed when the target passed within 2" of the detector objective lens.

Figure 30. IRIS analog response to insects.

12. **Infrared Sensor Detection Out of Apparent Field of View.** An interesting phenomenon was observed during a test using the tripod-mounted IRIS sensor head. Plexiglas and other plastic sheets were placed 18 inches in front of the sensor optics to determine the attenuation effect as an intruder walked through the field of view. For plexiglas, no analog response occurred for intrusions at a range of 15 ft. Another individual crossing the sensor field of view at a range of 28 ft produced alarm levels of analog at one location along the intrusion path – the sensor responded to a reflection, off the ceiling duct system (Figure 20), that by-passed the plexiglas shield.

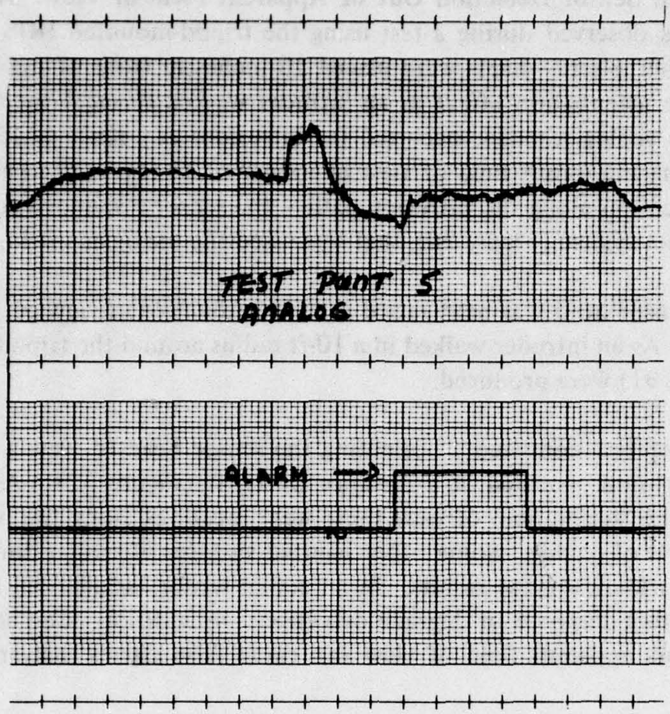
The sensor head was next raised 6 ft with the field of view perpendicular to the ceiling duct. As an intruder walked in a 10-ft radius around the tripod, alarm levels of analog (Figure 31) were produced.

Another test consisted of orienting the sensor head to view a row of sheet metal office partitions located at a distance of 12 ft (Figure 32). As an intruder walked behind the sensor field of view there were locations along the path that produced alarm levels of analog. Some other painted surfaces of similar dimensions were also tested with widely varying results. In an actual sensor installation, the reflection pattern could either improve or degrade detection. In addition, false alarm stimulus not in the sensors apparent field of view can cause false alarms that are difficult to resolve.

13. **Sensor Susceptibility to Intruder Countermeasures.** As previously stated, the detection performance for an infrared motion sensor is highly dependent on the contents of the scene, the intruders clothing, and the magnitude of the thermal gradients viewed.

a. **Stealthy Intrusions.** Figure 28 shows a typical wall section of Building 2093. Many items along the walls have different emissivities which tend to enhance intruder detection. Against this background, it was not possible using stealthy intrusions to pass undetected through the IRIS, Infralarm, or ADL detection envelopes.

The tripod-mounted IRIS sensor was next used to observe the analog response of an intruder at a range of 28 ft. The intruder made a determined effort to move as slowly as possible. In addition, the intruder was told to stop when the analog signal began to increase; he then waited at this location until the analog subsided. Using this technique, the intruder entered the detection envelope undetected when the background scene was reasonably uniform. As the intruder moved across the sensor field of view, the analog remained low until he passed in front of a large discontinuity, such as a metal cabinet, at which point the analog signal rapidly increased to alarm level and within a few seconds an output alarm was generated.



TEST CONDITIONS:

1. Detector field of view facing ceiling mounted duct constructed of galvanized sheet steel.

2. Detector mounted 6' high and intruder moving on 10' radius around detector.

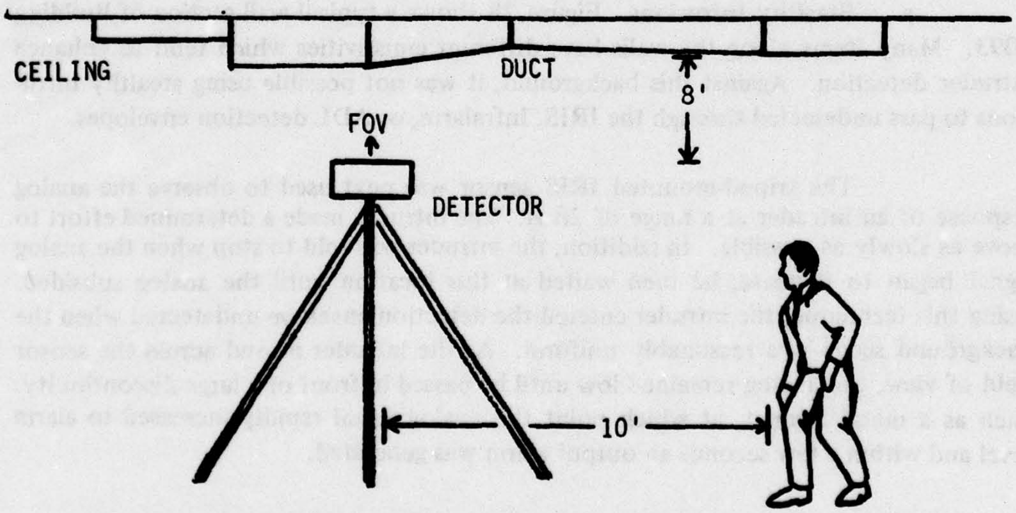
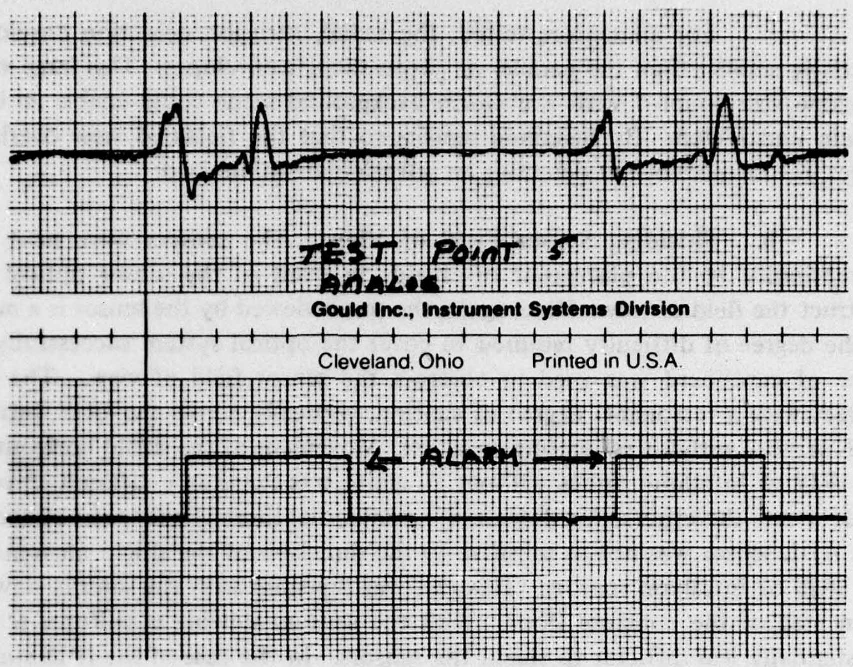


Figure 31. IRIS analog response (duct reflection) for intrusions out of the apparent field of view.



TEST CONDITIONS:

1. Detector facing flat painted metal surface.

2. Human target passes behind detector assembly.

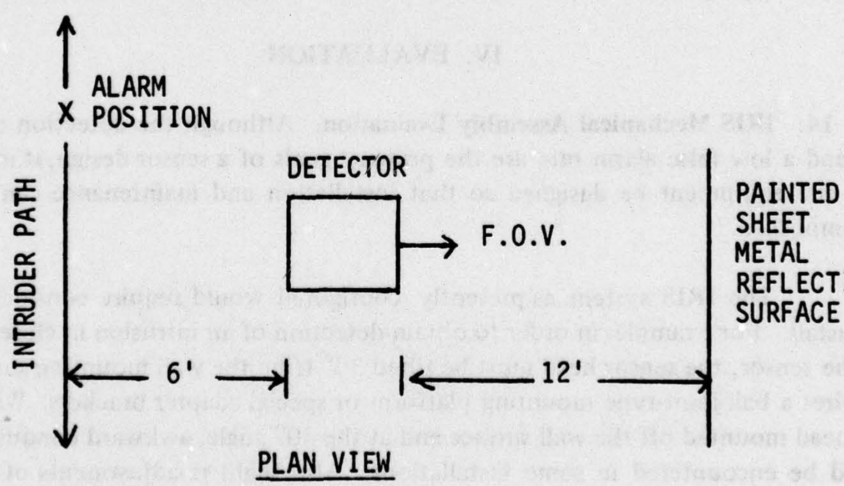


Figure 32. IRIS analog-response (office partition reflection) for intrusions out of the apparent field of view.

For all sensors tested, the radial intrusion detection envelope is substantially smaller than the parallel or perpendicular envelopes. This large variation in envelope size coupled with a uniform background scene could enable an intruder to remain undetected. By installing sensors so that the fields of view overlap at right angles, the chances of not detecting an intrusion are minimized.

b. **Shielding Sensor Field of View.** The sensors were next tested for susceptibility to the placement of shields in front of the sensor optical system to obstruct the field of view. Here, again, the scene viewed by the sensor is a major factor in the degree of difficulty required to cover the optical system successfully. A small piece of cardboard was used to obstruct the sensor field of view. The shield was moved, with a reasonable degree of caution, vertically across the IRIS, Infralarm, and ADL sensors without generating an alarm. Movement of the shield horizontally across the IRIS or Infralarm optics without an alarm was extremely difficult since this technique meets the criteria for detection; a sequential thermal change in adjacent sectors. The ADL sensor was not as sensitive to the direction of the shield movement as were the IRIS or Infralarm sensors. This test was repeated with the sensors viewing a large open area of the concrete floor. With the sensors viewing a uniform scene, it was substantially less difficult to shield the sensors. In the case of the IRIS and Infralarm sensors, the shield could be moved vertically in front of the optical system at a rate of ½ inch per second without producing an alarm. The ADL was shielded similarly without producing an alarm; however, the maximum rate was ¼ inch per second.

Single sensor installations where access to the rear of the sensor is possible could permit the use of this type of countermeasure. Proper precautions to minimize the placement of a sensor in a uniform scene or the use of multiple sensors with overlapping fields of view to protect each other would minimize this threat.

IV. EVALUATION

14. **IRIS Mechanical Assembly Evaluation.** Although the detection of an intruder and a low false alarm rate are the primary goals of a sensor design, it is important that the equipment be designed so that installation and maintenance can be readily accomplished.

The IRIS system as presently configured would require considerable labor to install. For example, in order to obtain detection of an intrusion in close proximity to the sensor, the sensor head must be tilted 30° from the wall mounting surface. This requires a ball-joint-type mounting platform or special adapter brackets. With the sensor head mounted off the wall surface and at the 30° angle, awkward conduit problems could be encountered in some installations. Also slight re-adjustments of the sensor field of view, as may be required to avoid false alarm stimulus or to provide the

coverage required, would not be possible. The ball-joint-type arrangement used on the Infralarm sensor is more versatile; however, these sensors are highly vulnerable to redirection by individuals with access to the area. Suitable locking devices or tamper switches would minimize this problem.

As previously discussed in paragraph 11g, the recessed optical housing will be an attractive landing pad or nesting area for some insects. In addition, individuals with access to the area could place objects in the lens housing that would not be obvious.

Some of the IRIS sensor head terminal-board screws require the use of a screwdriver at a 20° angle to the screw axis. In this position, the screwdriver blade comes in contact with electronic components on the printed circuit card, making it difficult to tighten the screw. The terminal board also requires a smaller lug than the one used in the control unit; a standard size for both units would be desirable.

Due to a lack of sufficient clearance between the lower sensor head printed wiring board and the conduit entrance, over-threading or normal conduit tolerances can result in the end of the conduit contacting and damaging the printed wiring board. A minimum of 1 inch clearance between the conduit opening and the printed wiring boards is necessary. Also there is not sufficient room in the enclosure to dress spare cable so that the sensor can be pulled out of the enclosure during installation or service.

The lever-type tamper switches used on the sensor heads and control unit have a tendency to catch on clothing, wiring, etc., and be broken. The plunger-type tamper switch with a pull-out service position is preferable.

The control unit terminal boards are extremely awkward to wire. With the control unit in its normal orientation, the terminal boards are upside down and the terminal designations are not clearly visible.

Removal of the control unit circuit board, should failure occur, would be a major task. Failure of sensor equipment in many areas often creates major security problems and rapid repair is essential. The capability to replace major subassemblies rapidly would be desirable.

15. **IRIS Electronic Circuit Evaluation.** During this evaluation, the IRIS detection performance was slightly superior to that of the Infralarm sensor; however, the IRIS false alarm rate at most test locations was substantially higher. The Infralarm sensor produced no false alarms during the same test period. In test locations D and E, during a period of unusually cold weather, the IRIS false alarm rate increased substantially. The cold weather increased the heating plant duty cycle and resulted in large floor-to-ceiling air temperature gradients. Susceptibility of the IRIS to this stimu-

lus appears to result from the use of a thermally controlled amplifier gain peaking circuit (previously described in paragraph 7b) and a 20-second window time (5 seconds for the Infralarm). Further optimization of these parameters should reduce the IRIS susceptibility to this stimulus.

The use of an analog test point can be a major factor in minimizing IRIS false alarms. For the IRIS at test location E (viewing furnace), a slight repositioning of the sensor resulted in a total elimination of false alarms because of the furnace. For the IRIS system, it would be desirable to have the sensor head analog signal available at the control unit and capable of being measured with a standard voltmeter.

For a multiple sensor head system such as the IRIS, the identification of a false alarming sensor can be difficult and time consuming, especially for infrequent false alarms. It would be desirable to have an LED indicator available in the control unit for each sensor head alarm line to indicate the receipt of a sensor alarm. The Tell Tale unit described previously performed this general function except it was located outside the protected area and required a manual reset of the LED indicators. An improved version of this technique is used in the Joint Services Interior Intrusion Detection System and should be considered for application to the IRIS. In the J-SIIDS version, the LED indicators are located in the control unit and indicate an alarm only when the sensor system is in the secure mode. In order to permit the area to be vacated, a timer is used to inhibit the LEDs for a period of time of up to 90 seconds after the control unit is placed in the secure mode. In addition, when the control unit is switched to secure, all previous alarm indications are extinguished. Any sensor generating an alarm after the exit timer expires will be indicated on the appropriate LED indicator. Upon receipt of the first alarm, a second timer activates and at the end of a specified time the remaining LEDs are inhibited until the control unit is again switched from access to secure.

The IRIS is designed to detect an intrusion by sensing the thermal change occurring in each sector as the intruder crosses the sensor field of view. Adjacent sectors produce alternate polarity pulses that are amplified and then level-detected. An alarm output is produced when two opposite polarity outputs meet the threshold requirements within 20 seconds of each other. During the false alarm susceptibility tests, it was noted that light bulbs, space heaters, and other concentrated heat sources when placed in a single sector could also produce an alarm when turned on or off. Figure 27 shows the resulting IRIS analog when viewing the heating plant flue pipe. As can be seen, the flue pipe easily saturates the thermopile amplifier. This saturation causes capacitors C5, C8, and C20 to charge to high d.c. levels. When the output amplifier starts to recover from saturation, discharging capacitors C5, C8, and C20 produce an opposite polarity output that exceeds the threshold within the 20-second window generating an alarm. This amplifier saturation effect can be prevented by input clamping or non-linear feedback techniques.

APPENDIX A

IRIS SENSOR HEAD DATA SHEETS

TEST

1. Determine the clock pulse period for each sensor head.

2. Determine the duration of the signal output for each sensor head.

SENSOR HEAD NUMBER	CLOCK PULSE START TIME TO REFERENCE (SECONDS)	PERIOD BETWEEN CLOCK PULSES, TWO MEASUREMENTS (SECONDS)		SIGNAL DURATION (SECONDS) FOR ALARM STIMULUS LESS THAN 2 SECONDS
1	7	1172	1171	19
3	332	998	996	14 (1)
5	555	860	859	15 (2)
7	366	1017	1000	16 (3)
8	260	669	704	19
9	298	771	766	15
4	260	1037	999	15
6	258	704	712	15

Signal is the Barnes term for a logic level out of the sensor head representing sensor detection, typically described as 20 seconds in duration.

(1) - Follow on signal occurs 4 to 9 seconds after termination of first signal output. Follow on duration was 15 seconds.

(2) - Follow on signal occurs 5 to 10 seconds after termination of first signal output. Follow on duration was 13 seconds.

(3) - Follow on signal occurs 1 to 3 seconds after termination of first signal output. Follow on duration was 15 seconds.

Test Conditions

1. All eight detector lens initially capped to inhibit intruder detection.

2. At 5 minute intervals uncap each lens and verify intruder detection; continue testing for one hour

TIME	DET. NO.1	DET. NO.3	DET. NO.4	DET. NO.5	DET. NO.6	DET. NO.7	DET. NO.8	DET. NO.9
0900	A	A	A	A	A	A	A	A
0905	A	A	A	A	A	A	A	A
0910	A	A	A	A	A	A	A	A
0915	A	A	A	A	A	A	A	A
0920	A	A	A	A	A	A	A	A
0925	A	A	A	A	A	A(1)	A	A
0930	A	A	A	A	A	A	A	A
0935	A	A	A	A	A	A	A	A
0940	A	A	A	A	A	A	A	A
0945	A	A	A	A	A	A	A	A
0950	A	A	A	A	A	A	A(1)	A
0955	A	A	A	A	A	A	A	A
1000	A	A	A	A	A	A	A	A

(1) Less than 5 second delay before alarm occurs.

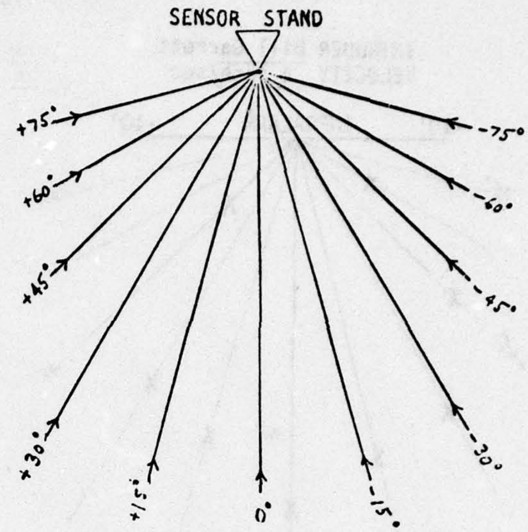
APPENDIX B

IRIS, INFRALARM, AND ADL DETECTION ENVELOPES AND DATA SHEETS

INTRUDER GARRETT (6' 2" 230 lbs)
VELOCITY ≈4"/sec.

RADIAL PATHS (1)

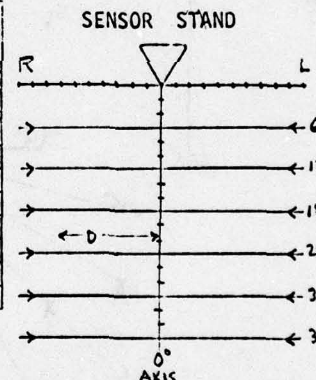
ANGLE	BARNES INFRALARM	ADL	BARNES IRIS
+75°	NA	NA	1'
+60°	3	NA	18's
+45°	15	NA	15
+30°	21	NA	27's
+15°	22	10'	22
0	25	7'	25'
-15°	21	6'	25'
-30°	19	6'	27
-45°	6	7	14
-60°	NA	NA	6
-75°	NA	NA	1



(1) DETECTION RANGE (FEET)

PERPENDICULAR PATHS (2)

DISTANCE DOWN 0° AXIS	BARNES INFRALARM		ADL		BARNES IRIS	
	R	L	R	L	R	L
3	3	3	-2	1	4	5
6	9	9	5	7	9	9
12	12	7	3	4	12	12
18	12	9	NA	NA	12	9
24	12	12	NA	NA	12	12
30	10	10	NA	NA	10	10
36	13	10	NA	NA	13	10
45	10	6	NA	NA	12	9

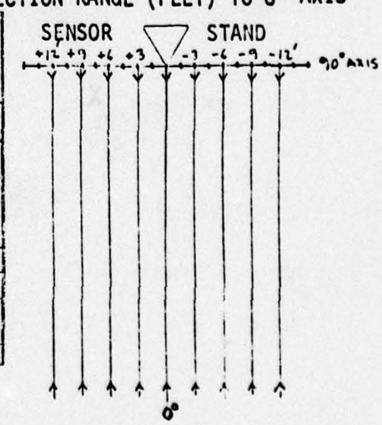


(2) DETECTION RANGE (FEET) TO 0° AXIS

PARALLEL PATHS (3)

DISTANCE PERP. TO 0° AXIS	BARNES INFRALARM		ADL		BARNES IRIS	
	IN	OUT	IN	OUT	IN	OUT
+12	29	12	NA	15	32	12
+ 9	15	12	NA	12	28	9
+ 6	29	5	11	9	18	5
+ 3	27	6	8	7	39	3
0	24	6	6	6	24	1
- 3	19	7	6	4	28	1
- 6	17	9	7	7	30	3
- 9	25	12	8	12	24	9
-12	33	13	NA	NA	42	12

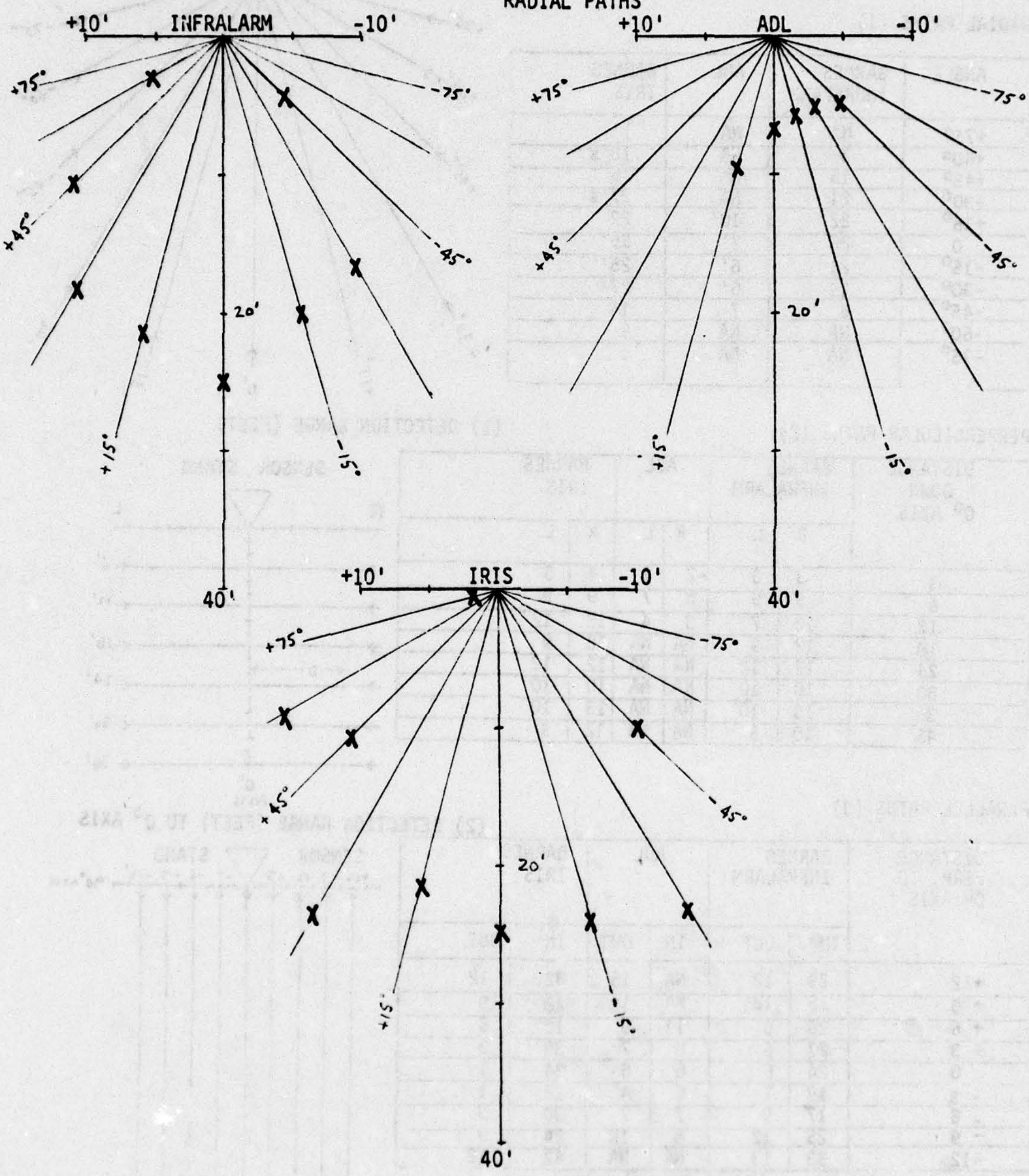
(3) Detection range (feet) to 90° axis



INTRUSION TESTS
BUILDING 2093

INTRUDER Bill Garrett
VELOCITY 4 inch/sec

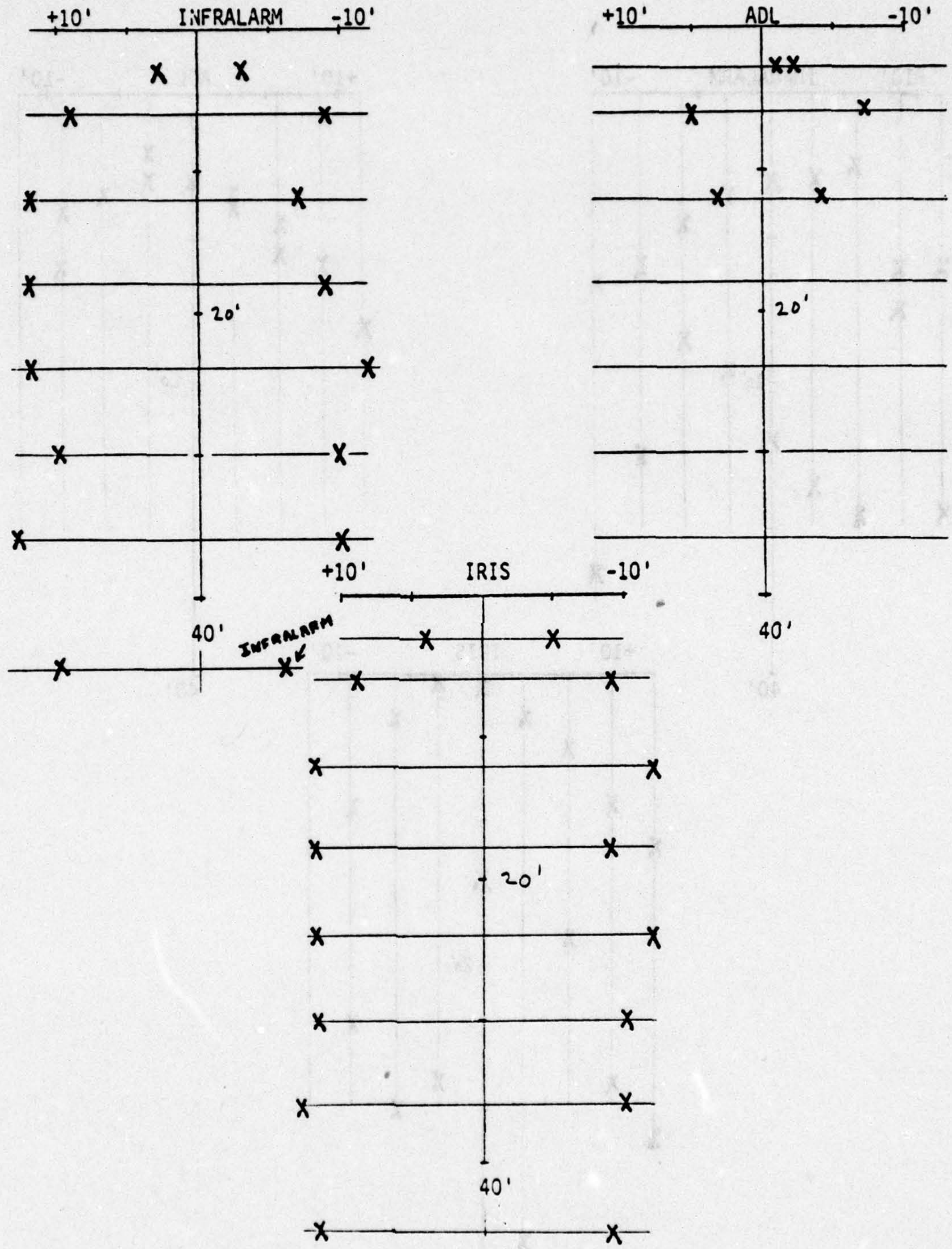
RADIAL PATHS



INTRUSION TESTS BUILDING 2093

INTRUDER Bill Garrett
VELOCITY 4 inch/sec

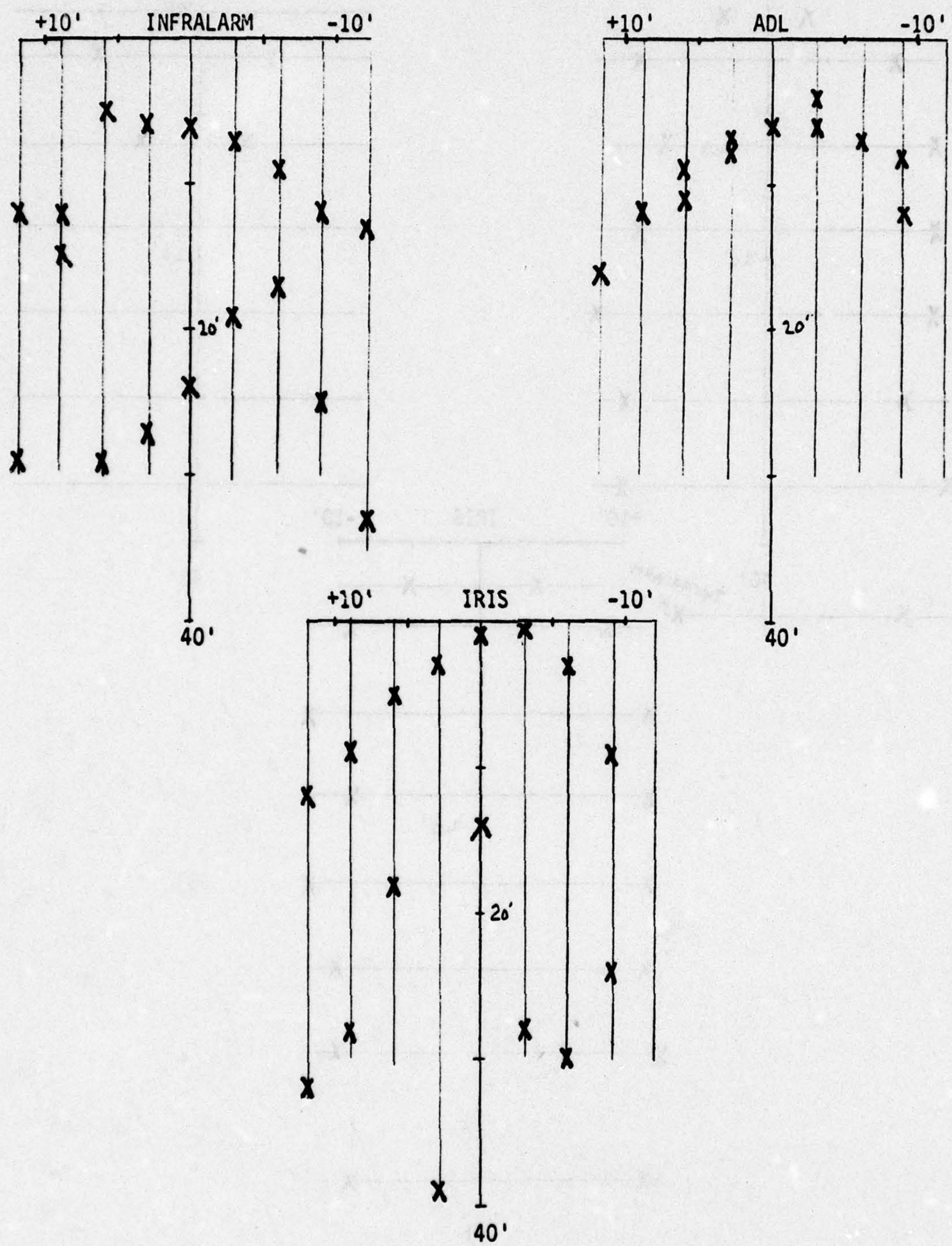
PERPENDICULAR PATHS



INTRUSION TESTS BUILDING 2093

INTRUDER Bill Garrett
VELOCITY 4 inch/sec

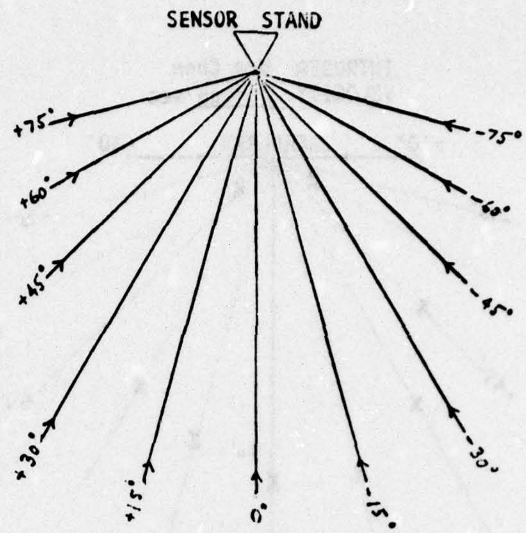
PARALLEL PATHS



INTRUDER Wen Chen (5' 6" 160 lbs)
VELOCITY ≈4 inch/sec

RADIAL PATHS (1)

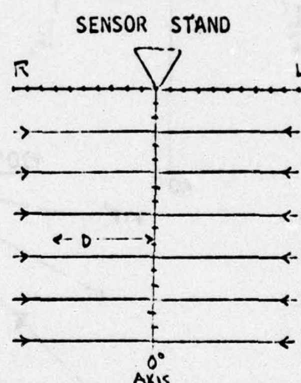
ANGLE	BARNES INFRALARM	ADL	BARNES IRIS
+75°	NA	NA	2
+60°	3	NA	5
+45°	14	14	14
+30°	19	9	25
+15°	22	8	22
0	22	11	20
-15°	20	6	23
-30°	18	10	24
-45°	3	NA	7
-60°	NA	NA	1
-75°	NA	NA	NA



(1) DETECTION RANGE (FEET)

PERPENDICULAR PATHS (2)

DISTANCE DOWN 0° AXIS	BARNES INFRALARM		ADL		BARNES IRIS	
	R	L	R	L	R	L
6	6	6	2	6	0	6
12	11	9	8	3	8	12
18	9	9	NA	NA	12	12
24	8	8	NA	NA	12	12
30	10	9	NA	NA	10	12
36	7	5	NA	NA	12	12

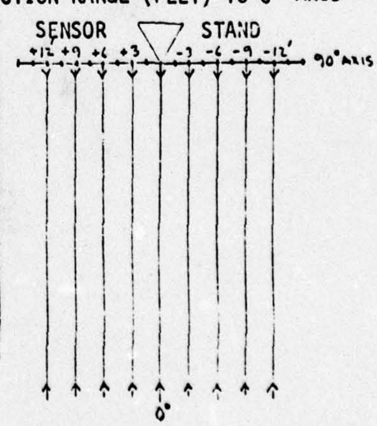


(2) DETECTION RANGE (FEET) TO 0° AXIS

PARALLEL PATHS (3)

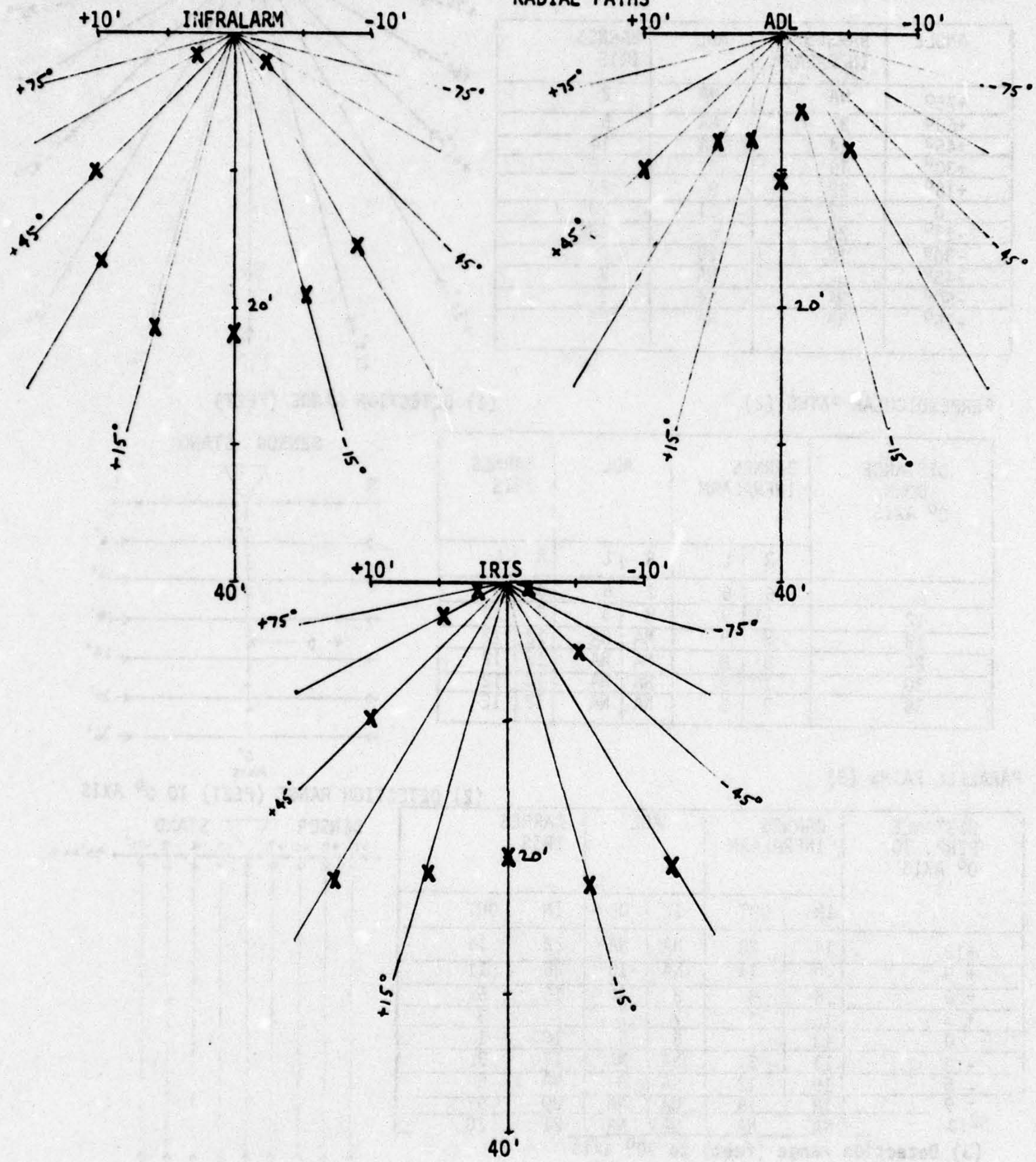
DISTANCE PERP. TO 0° AXIS	BARNES INFRALARM		ADL		BARNES IRIS	
	IN	OUT	IN	OUT	IN	OUT
+12	14	20	NA	NA	22	16
+ 9	26	11	NA	10	26	11
+ 6	16	8	8	8	16	5
+ 3	15	3	7	7	7	3
0	13	3	8	8	18	1
- 3	13	3	NA	NA	17	3
- 6	19	12	NA	8	NA	6
- 9	18	15	NA	NA	30	9
-12	NA	NA	NA	NA	21	18

(3) Detection range (feet) to 90° axis



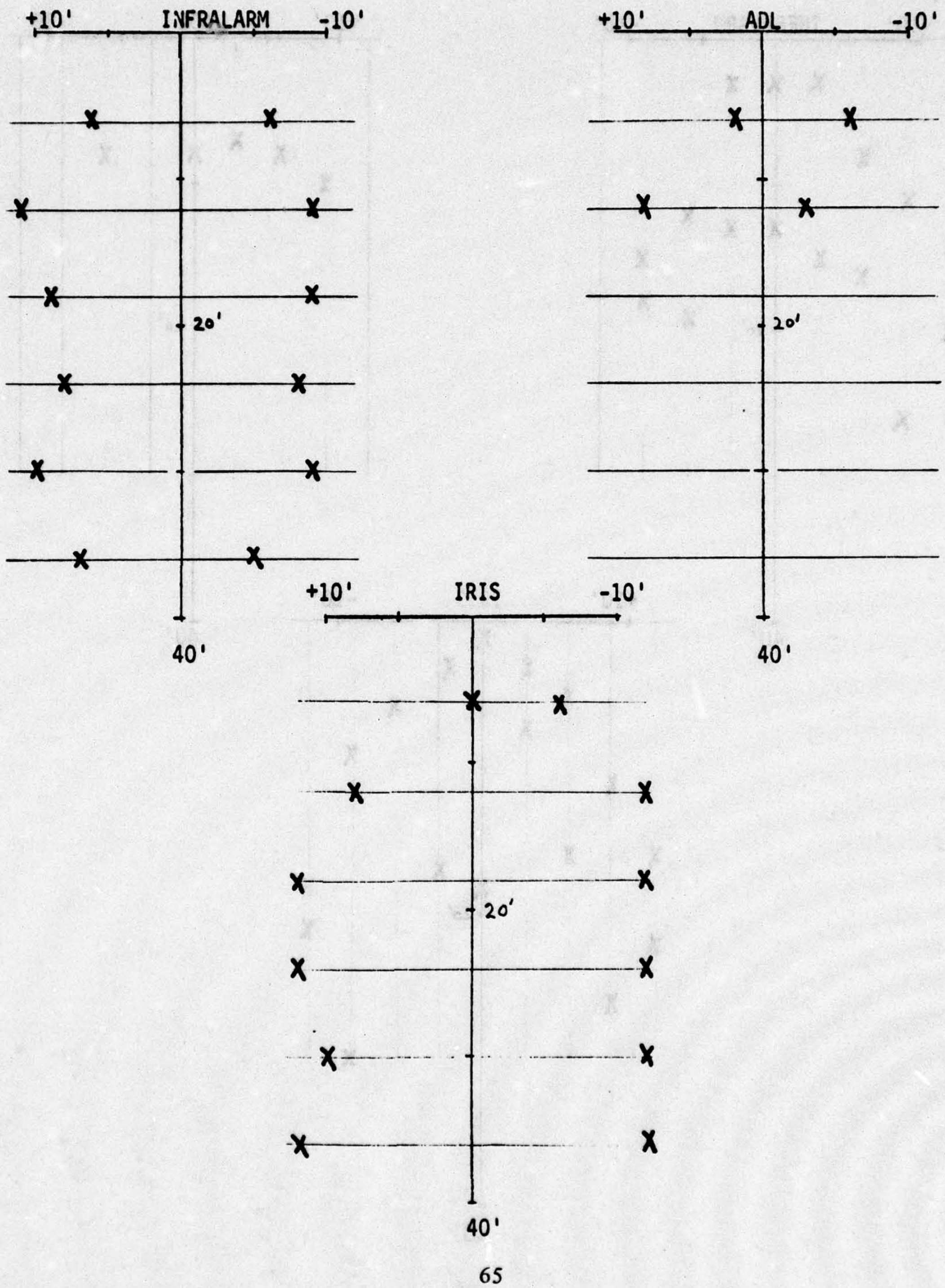
INTRUDER Wen Chen
VELOCITY 4 inch/sec

RADIAL PATHS



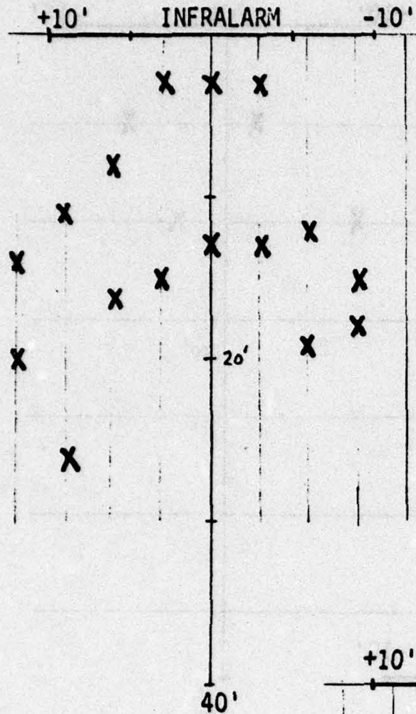
INTRUDER Wen Chen
VELOCITY 4 inch/sec

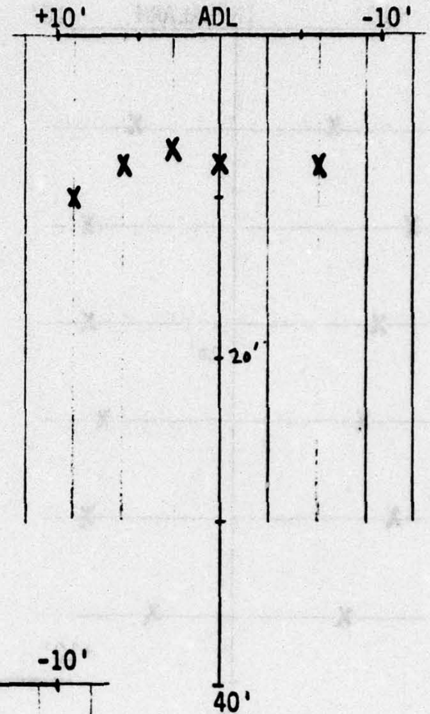
PERPENDICULAR PATHS

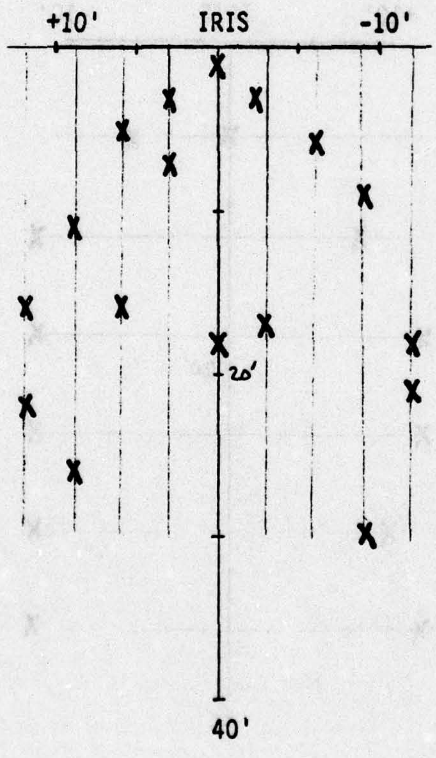


INTRUDER Wen Chen
VELOCITY 4 inch/sec

PARALLEL PATHS



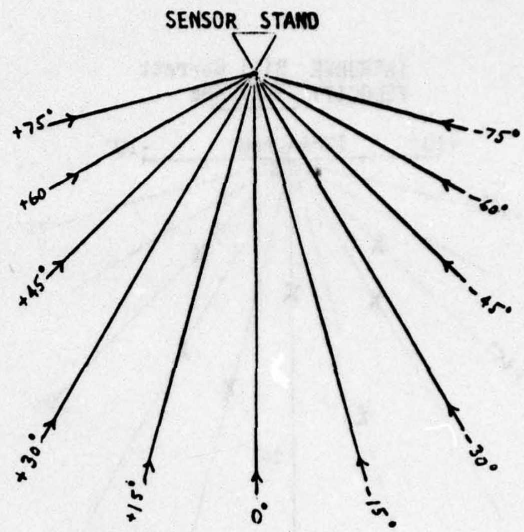




INTRUDER GARRETT (6' 2" 230 lbs)
VELOCITY 3'/sec

RADIAL PATHS (1)

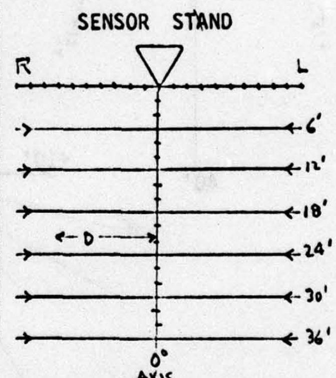
ANGLE	BARNES INFRALARM	ADL	BARNES IRIS
$+75^0$	NA	NA	1
$+60^0$	NA	NA	6
$+45^0$	8	NA	6
$+30^0$	11	NA	11
$+15^0$	18	9	18
0	9	6	9
-15^0	16	6	33
-30^0	15	5	25
-45^0	9	3	7
-60^0	1	NA	4
-75^0	NA	NA	1



(1) DETECTION RANGE (FEET)

PERPENDICULAR PATHS (2)

DISTANCE DOWN 0^0 AXIS	BARNES INFRALARM		ADL		BARNES IRIS	
	R	L	R	L	R	L
3	2	1	1	0	2	3
6	5	4	2	2	5	5
12	9	9	6	6	9	9
18	10	6	NA	NA	10	6
24	8	9	NA	NA	8	9
30	6	6	NA	NA	6	7
36	3	9	NA	NA	3	12
45	NA	9	NA	NA	15	9
9	7	5	5	5	7	7

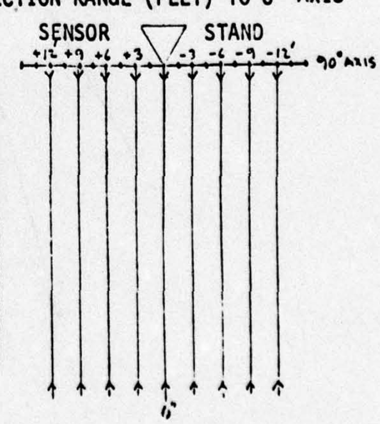


(2) DETECTION RANGE (FEET) TO 0^0 AXIS

PARALLEL PATHS (3)

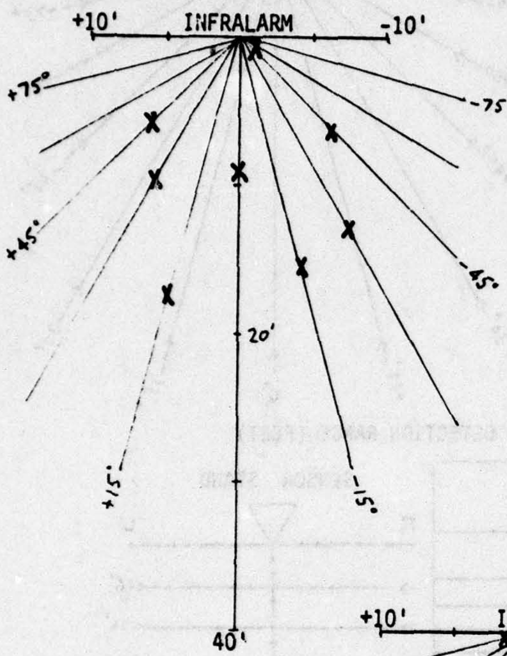
DISTANCE PERP. TO 0^0 AXIS	BARNES INFRALARM		ADL		BARNES IRIS	
	IN	OUT	IN	OUT	IN	OUT
+12	28	15	12	18	28	15
+ 9	20	9	9	12	20	9
+ 6	20	6	6	9	34	6
+ 3	9	4	9	4	20	3
0	10	3	9	8	18	1
- 3	12	5	8	5	24	5
- 6	28	9	3	7	28	6
- 9	24	10	8	12	24	10
-12	33	14	NA	NA	30	14

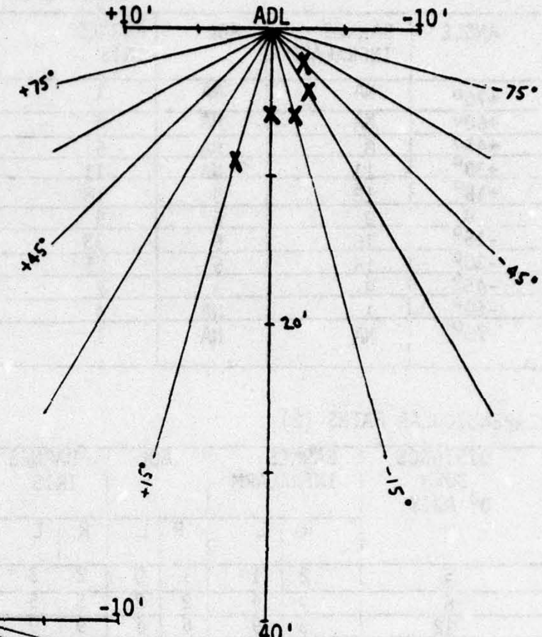
(3) Detection range (feet) to 90^0 axis

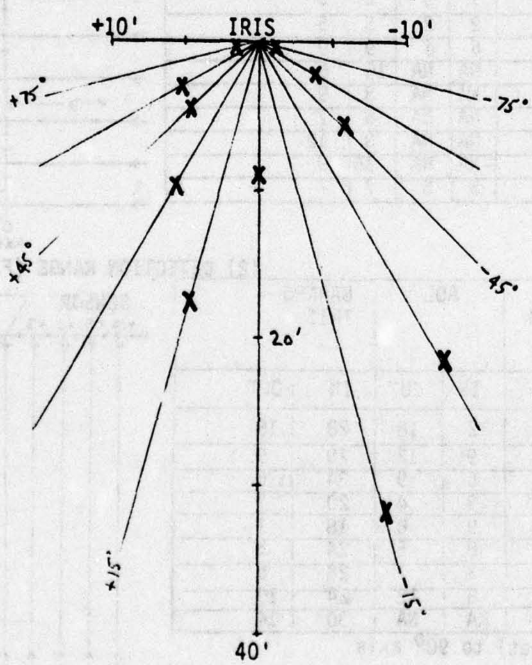


INTRUDER Bill Garrett
VELOCITY 3 ft/sec

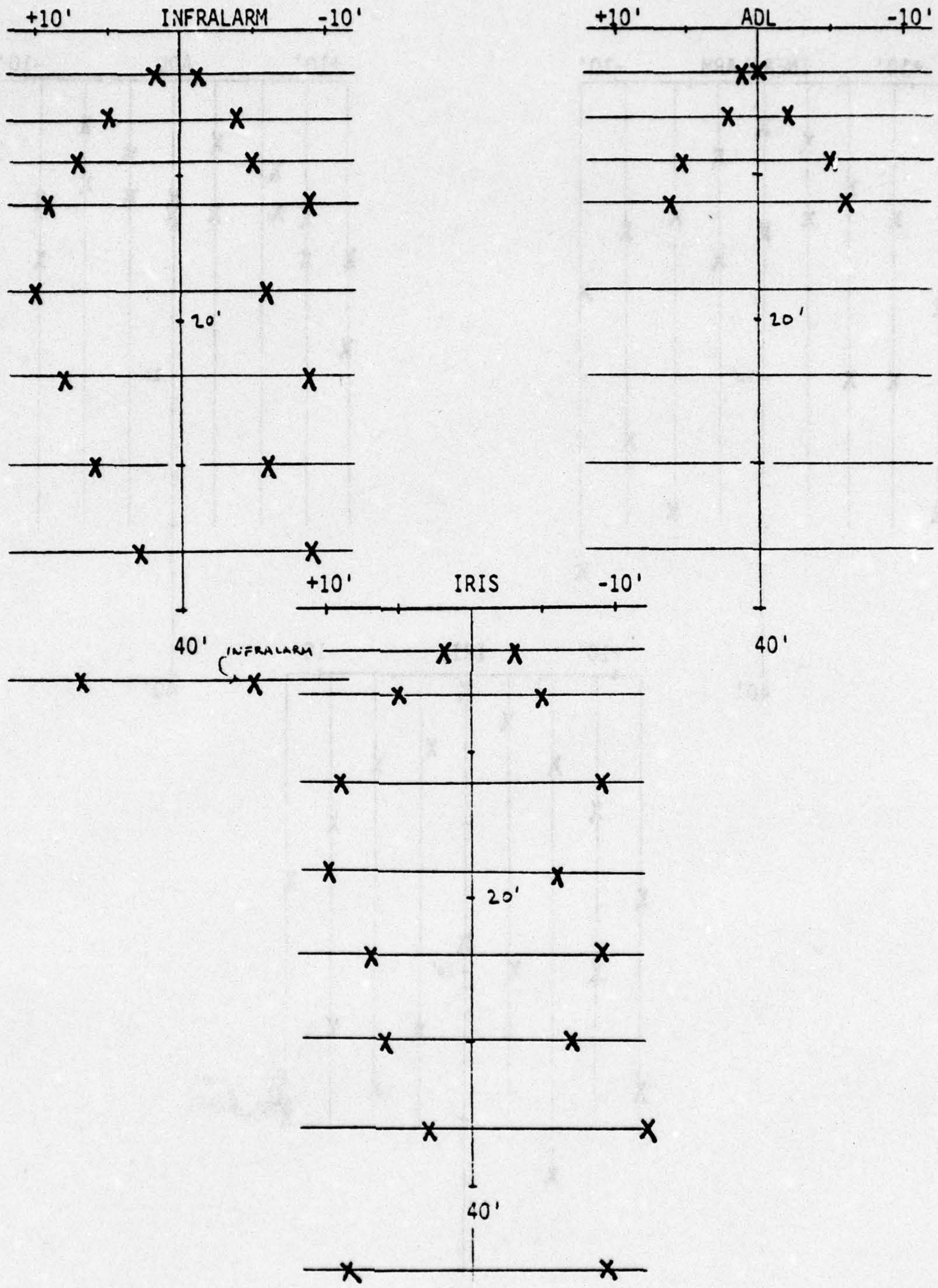
RADIAL PATHS





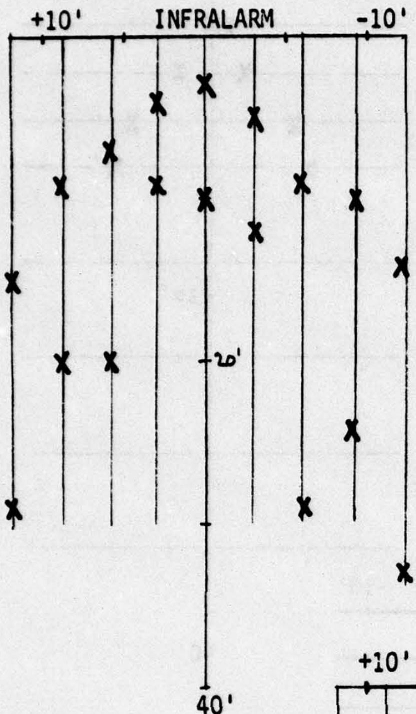


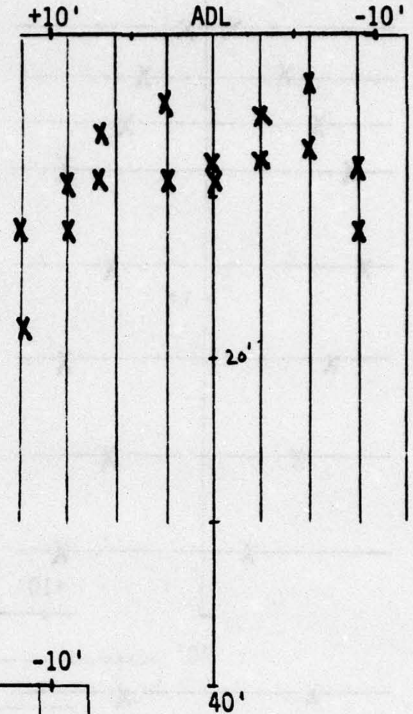
INTRUDER Bill Garrett PERPENDICULAR PATHS
VELOCITY 3 ft/sec

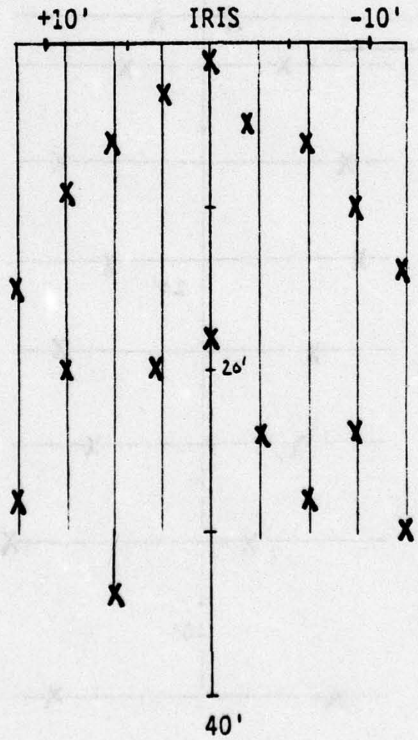


INTRUDER Bill Garrett
VELOCITY 3 ft/sec

PARALLEL PATHS



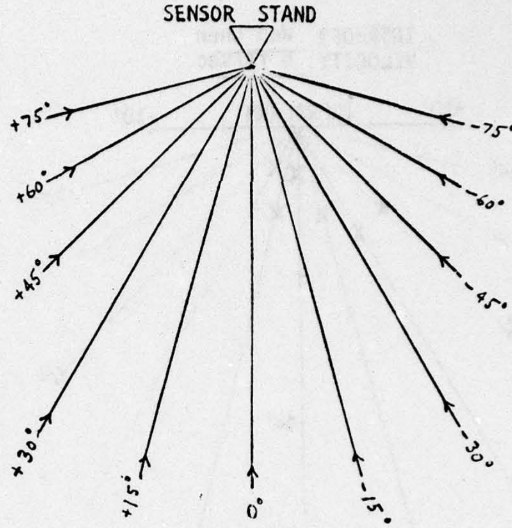




INTRUDER Wen Chen (5' 6" 160 lbs)
VELOCITY ≈6ft/sec.

RADIAL PATHS (1)

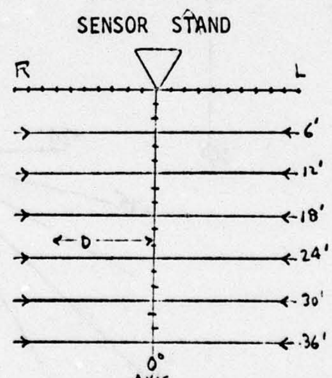
ANGLE	BARNES INFRALARM	ADL	BARNES IRIS
+75°	NA	NA	NA
+60°	NA	NA	NA
+45°	8	NA	3
+30°	8	NA	3
+15°	6	4	4
0	3	3	21
-15°	6	3	3
-30°	3	NA	9
-45°	NA	NA	9
-60°	NA	NA	NA
-75°	NA	NA	NA



(1) DETECTION RANGE (FEET)

PERPENDICULAR PATHS (2)

DISTANCE DOWN 0° AXIS	BARNES INFRALARM		ADL		BARNES IRIS	
	R	L	R	L	R	L
6	0	0	-3	3	0	-3
12	6	-6	3	3	6	-6
18	3	-3	NA	NA	NA	-6
24	0	0	NA	NA	9	-9
30	3	-3	NA	NA	3	-3
36	-9	9	NA	NA	-9	9

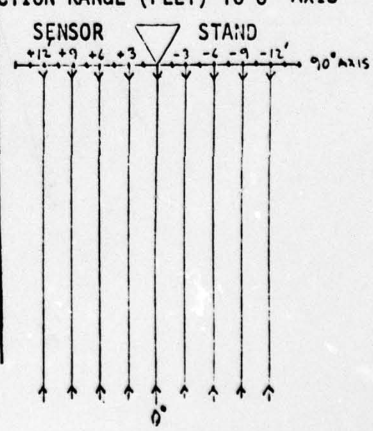


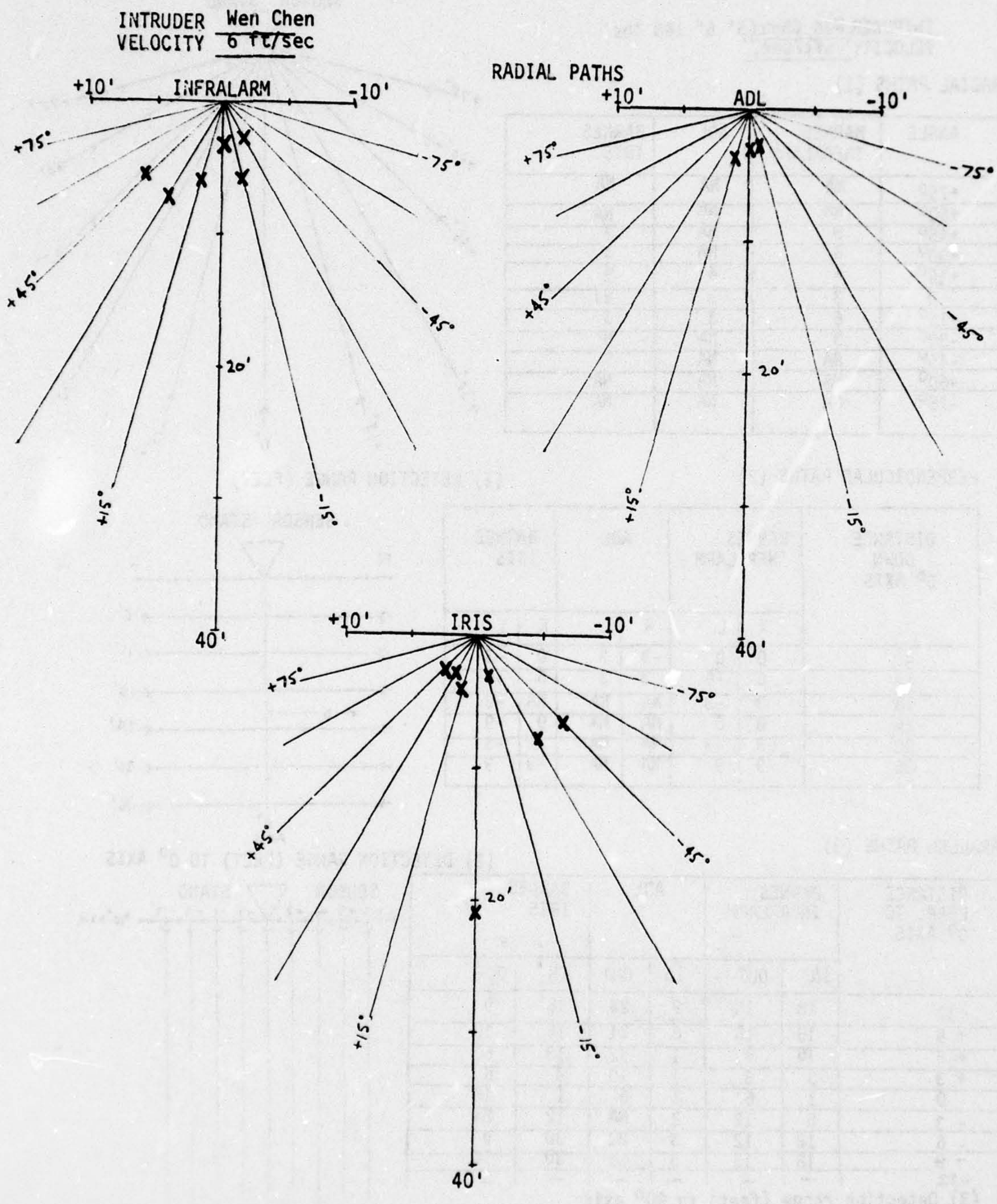
(2) DETECTION RANGE (FEET) TO 0° AXIS

PARALLEL PATHS (3)

DISTANCE PERP. TO 0° AXIS	BARNES INFRALARM		ADL		BARNES IRIS	
	IN	OUT	IN	OUT	IN	OUT
+12	18	15	9	24	18	9
+ 9	15	15	6	21	15	10
+ 6	16	6	1	12	18	6
+ 3	3	6	1	10	9	6
0	1	6	1	6	1	10
- 3	6	12	2	NA	12	24
- 6	18	12	3	20	30	9
- 9	18	15	3	20	30	10
-12	—	—	—	—	—	—

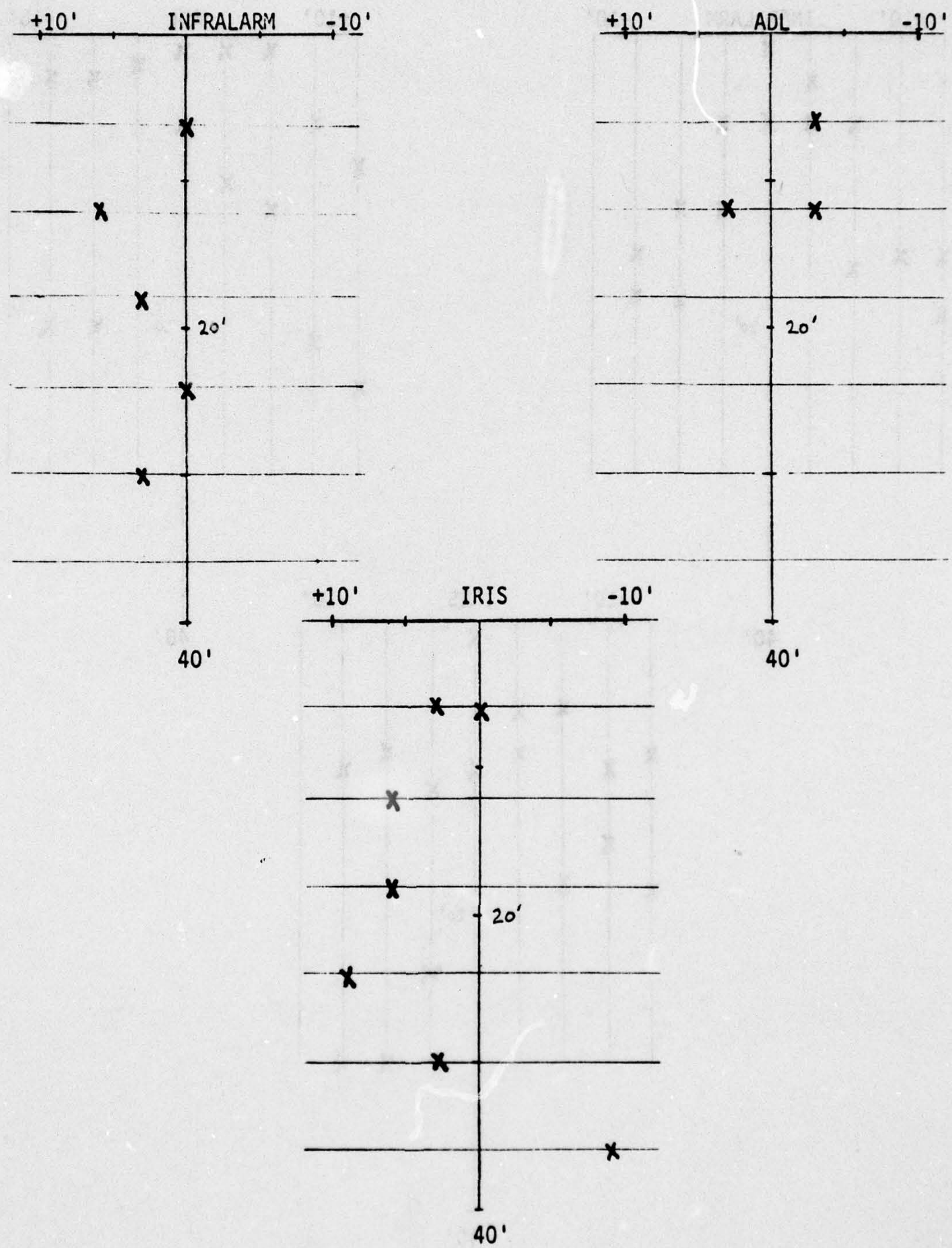
(3) Detection range (feet) to 90° axis




INTRUDER Wen Chen
VELOCITY 6 ft/sec
RADIAL PATHS
INFRALARM
+10'
-10'
+75°
-75°
+45°
-45°
+15°
-15°
20'
40'
ADL
+10'
-10'
+75°
-75°
+45°
-45°
+15°
-15°
20'
40'
IRIS
+10'
-10'
+75°
-75°
+45°
-45°
+15°
-15°
20'
40'

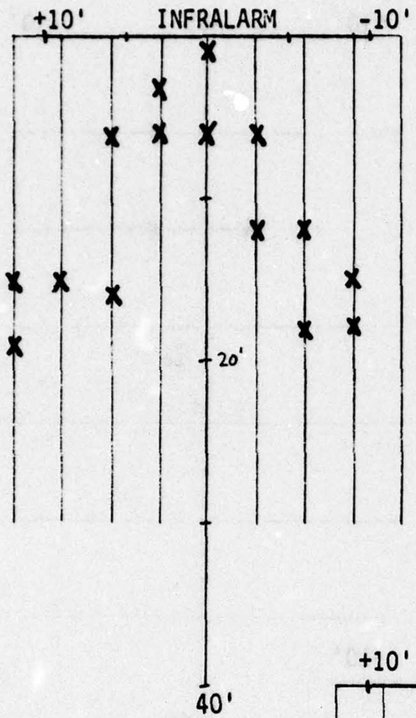
INTRODER Wen Chen
VELOCITY 6 Ft/sec

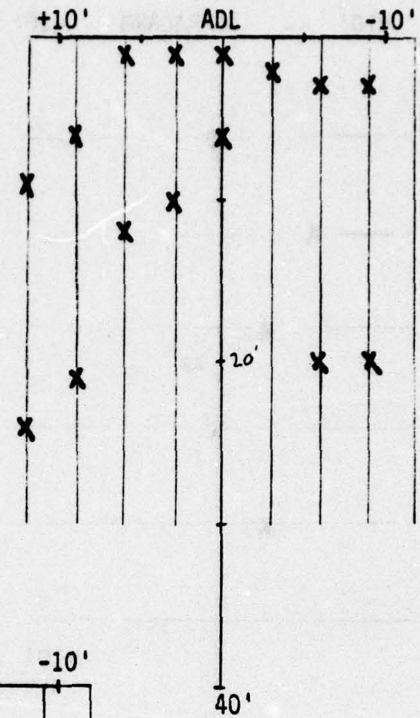
PERPENDICULAR PATHS

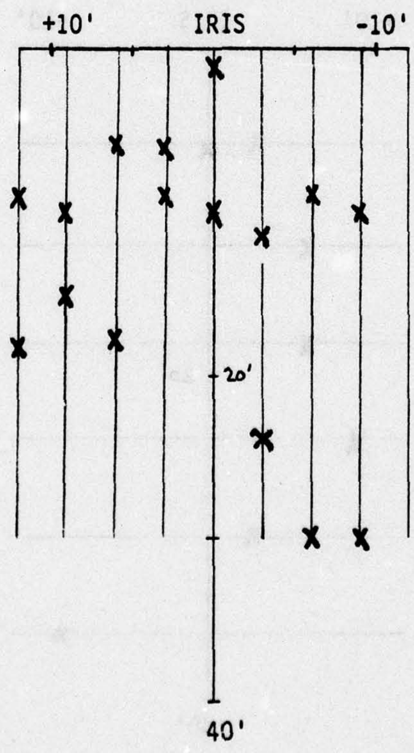


INTRUDER Wen Chen
VELOCITY 6 ft/sec

PARALLEL PATHS





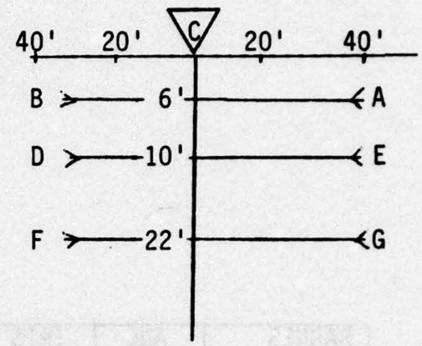


RUNNING

INTRUDER: Pat Kerfoot, 5'5", 135 lbs.

VELOCITY: High Speed (H) 20-23 ft/sec
Med. Speed (M) 14-16 ft/sec
Low Speed (L) 10-12 ft/sec

Temperature: 70^{o}F Intruder wearing long sleeve shirt.
60^{o}F Intruder wearing jacket.



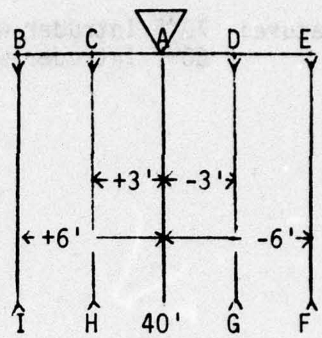
BARNES INFRALARM		ADL		IRIS		STARTING POSITION	SPEED
70^{o}F	60^{o}F	70^{o}	60^{o}	70^{o}	60^{o}		
NA	NA	A	NA	NA	NA	A	HIGH
NA	NA	A	A	NA	NA	B	
NA	NA	A	A	A	A	D	
NA	NA	A	A	A	A	E	
A	NA	NA	NA	A	A	G	
A	A	NA	NA	A	A	F	
NA	NA	A	NA	A	NA	A	MEDIUM
A	NA	A	A	NA	NA	B	
NA	NA	A	A	A	A	D	
NA	A	A	A	A	A	E	
A	A	NA	NA	A	A	G	
A	A	NA	NA	A	A	F	
NA	NA	A	A	NA	A	A	LOW
A	NA	A	A	A	A	B	
A	A	A	A	A	A	D	
A	A	A	A	A	A	E	
A	A	NA	NA	A	A	G	
A	A	NA	NA	A	A	F	

RUNNING

INTRUDER: Pat Kerfoot, 5'5", 135 lbs., long sleeve shirt

VELOCITY: High Speed (H) 20-23 ft/sec
Med. Speed (M) 14-16 ft/sec
Low Speed (L) 10-12 ft/sec

Room Temperature; 64°F



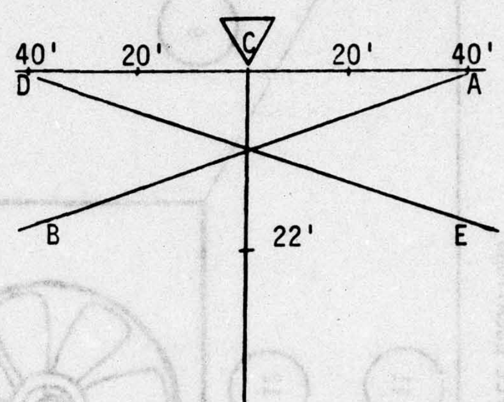
BARNES INFRALARM	ADL	IRIS	STARTING POSITION	SPEED
NA	NA	NA	E	HIGH
NA	NA	A	F	
A	NA	A	B	
A	NA	A	I	
NA	NA	A	D	
NA	NA	NA	G	
A	NA	A	C	
A	NA	NA	H	
NA	NA	NA	E	MEDIUM
A	NA	A	F	
NA	NA	NA	B	
A	A	A	I	
A	A	A	D	
NA	NA	A	G	
A	NA	A	C	
A	NA	NA	H	
A	NA	NA	E	LOW
A	NA	A	F	
NA	NA	A	B	
A	NA	A	I	
A	A	A	D	
A	A	A	G	
A	A	A	C	
A	A	A	H	

RUNNING

INTRUDER: Pat Kerfoot, 5'5", 135 lbs.

VELOCITY: High Speed (H) 20-23 ft/sec
Med. Speed (M) 14-16 ft/sec
Low Speed (L) 10-12 ft/sec

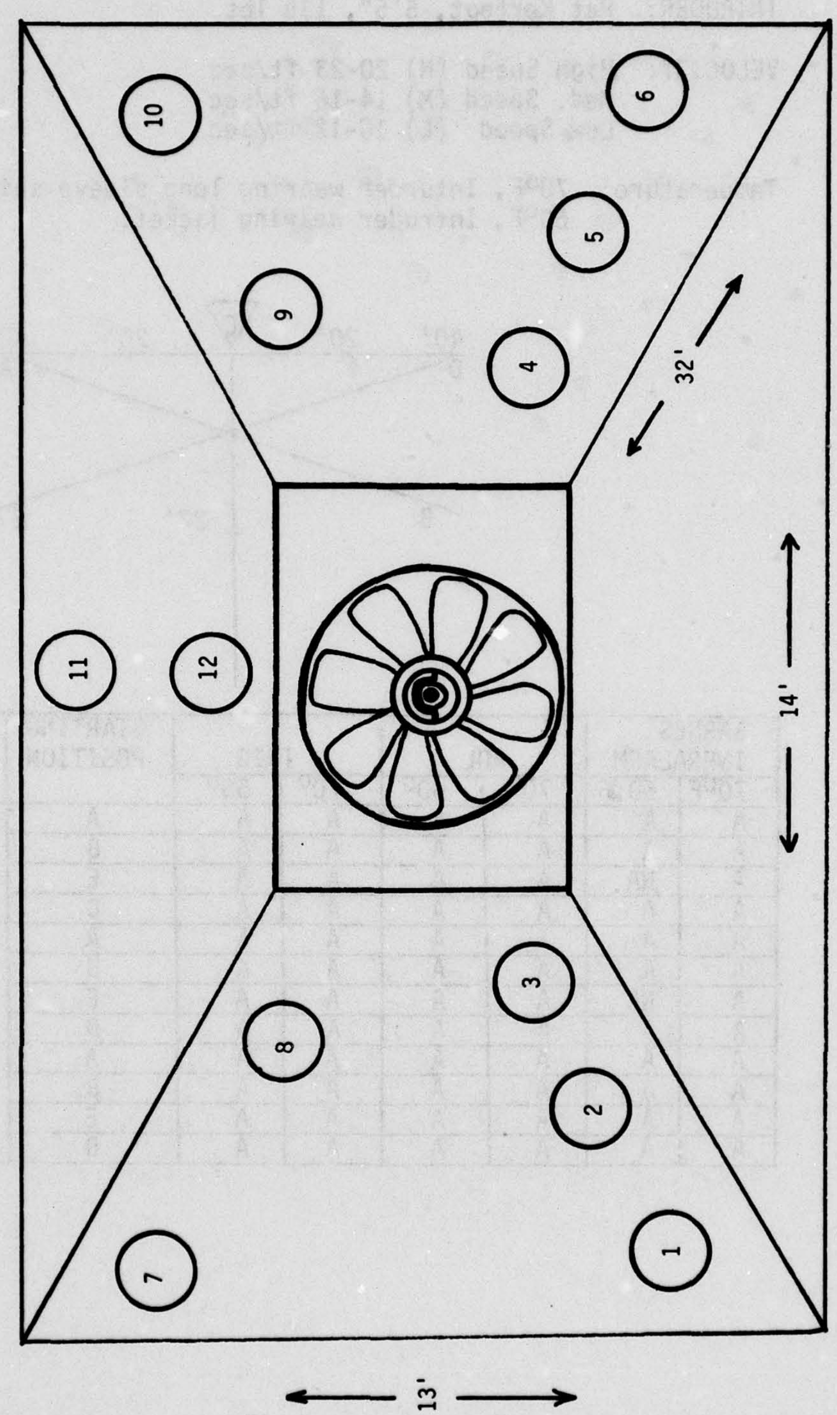
Temperature: 70^{o}F, Interder wearing long sleeve shirt.
60^{o}F, Intruder wearing jacket.



BARNES INFRALARM		ADL		IRIS		STARTING POSITION	SPEED
70^{o}F	60^{o}F	70^{o}	60^{o}	70^{o}	60^{o}		
A	A	A	A	A	A	A	HIGH
A	A	A	A	A	A	B	
A	NA	A	A	A	A	E	
A	A	A	A	A	A	D	
A	A	A	A	A	A	A	MEDIUM
A	A	A	A	A	A	B	
A	NA	A	A	A	A	E	
A	A	A	A	A	A	D	
A	A	A	A	A	A	A	LOW
A	A	A	A	A	A	B	
A	A	A	A	A	A	E	
A	A	A	A	A	A	D	

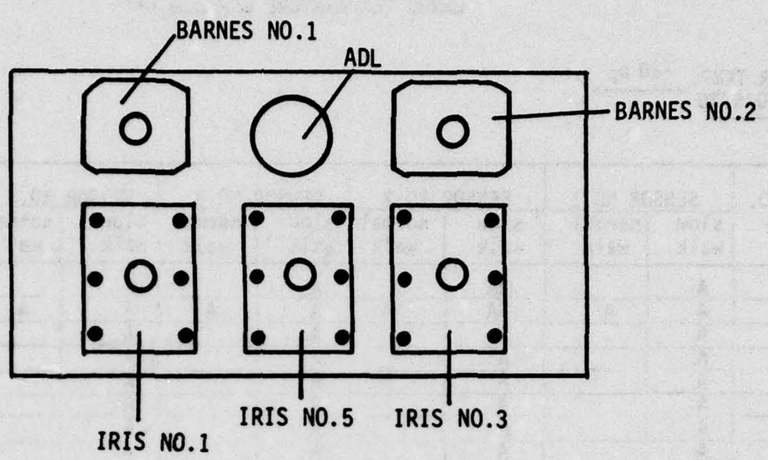
APPENDIX C

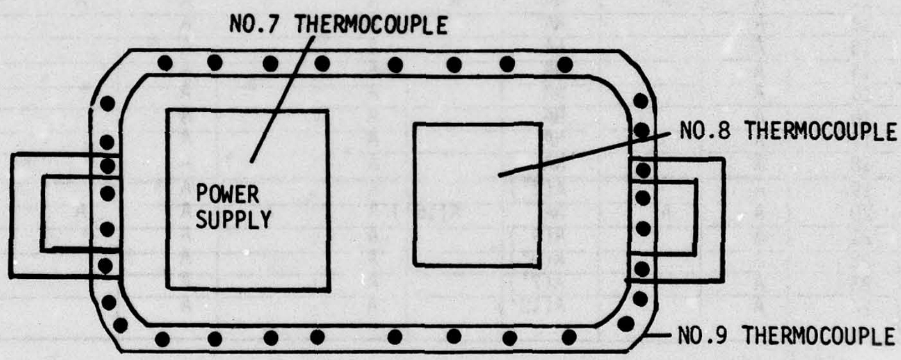
IRIS, INFRALARM, AND ADL DATA SHEETS FOR ENVIRONMENTAL TESTS



ENVIRONMENTAL CHAMBER
AIR TEMPERATURE
THERMOCOUPLE LOCATIONS

THERMOCOUPLE LOCATIONS
FOR INTRUSION DETECTORS





IRIS CONTROL UNIT

THERMOCOUPLE		
NO. 1	BARNES NO.1	Inside Electronics Package
NO. 2	ADL	Inside Electronics Package
NO. 3	BARNES NO.2	Inside Electronics Package
NO. 4	IRIS DETECTOR NO.1	Inside Electronics Package
NO. 5	IRIS DETECTOR NO.5	Inside Electronics Package
NO. 6	IRIS DETECTOR NO.3	Inside Electronics Package
NO. 7	IRIS CONTROL UNIT	Inside Electronics Package Rear Power Supply
NO. 8	IRIS CONTROL UNIT	Inside Electronics Package Over Circuit Card
NO. 9	IRIS CONTROL UNIT	Enclosure Casting
NO. 10	ENVIRONMENTAL CHAMBER AIR TEMPERATURE	

LARGE TEMPERATURE CHAMBER (1)

CHAMBER TEMP. -20 °F
DATE 10/5/76

PATH NO.	SENSOR NO.1		SENSOR NO.2		SENSOR NO.3		SENSOR NO.4	
	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk
1	A		NA		A		A	
2	A	A	NA	NA	A	A	A	A
3	A		A		A		A	
4	A		A		A		A	
5	A		A		A		A	
6	A		A		A		A	
7	A		A		A		A	
8	A		A		A		A	
9	A		A		A		A	
10	A		A		A		A	
11	A	A	NA	A	A	A	A	A
12	A		NA		A		A	
13	A		NA		A		A	
14	A		NA		A		A	
15	A		NA		A		A	
16	A		NA		A		A	
17	A		NA		A		A	
18	A		NA		A		A	
19	A		A(7')		A		A	
20	A	A	NA	A(15')	A	A	A	A
21	A		A(9')		A		A	
22	A		A(9')		A		A	
23	A		A(7')		A		A	
24	A		A(12')		A		A	

EQUIPMENT TEMPERATURE (°F)

THERMOCOUPLE NO.	START TEST	FINISH TEST
1	-18	-12.8
2	-13	- 5.9
3	-17.4	-12.1
4	-18.9	-16.3
5	-19.0	-16.5
6	-18.5	-15.8
7	+.1	+1.4
8	-6.3	-3.8
9	-20.2	-16.5
10	-21.3	-13.3

NOTES:
(1) H.E.T.C. Heavy Equipment Test Chamber
NA - No Alarm Traversing Entire Path
A - Sensor Alarm
SENSOR NO.1 - Barnes Infralarm
SENSOR NO.2 - ADL Model 6400
SENSOR NO.3 - Barnes Iris System
SENSOR NO.4 - Barnes Infralarm

LARGE TEMPERATURE CHAMBER (1)

CHAMBER TEMP. $0^{o}F$
DATE 10/5/76

PATH NO.	SENSOR NO.1		SENSOR NO.2		SENSOR NO.3		SENSOR NO.4	
	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk
1	A		A		A		A	
2	A		A		A		A	
3	A		A		A		A	
4	A		A		A		A	
5	A		A		A		A	
6	A		A		A		A	
7	A		A		A		A	
8	A		A		A		A	
9	A		A		A		A	
10	A		A		A		A	
11	A		A		A		A	
12	A	A	NA	A	A	A	A	
13	A	A	NA	NA	A	A	A	A
14	A		NA		A		A	
15	A		NA		A		A	
16	A		NA		A		A	
17	A		NA		A		A	
18	A		NA		A		A	
19	A		A		A		A	
20	A		A		A		A	
21	A		A(7')		A		A	
22	A		A		A		A	
23	A		A(9")		A		A	
24	A		A		A		A	

EQUIPMENT TEMPERATURE (^{o}F)

THERMOCOUPLE NO.	START TEST	FINISH TEST
1	2.6	6.9
2	6.9	12.7
3	3.1	7.5
4	1.9	4.0
5	1.9	3.8
6	2.3	4.4
7	20.3	21.1
8	13.5	15.8
9	.6	3.7
10	.4	6.4

NOTES:
(1) H.E.T.C. Heavy Equipment Test Chamber
NA - No Alarm Traversing Entire Path
A - Sensor Alarm
SENSOR NO.1 - Barnes Infralarm
SENSOR NO.2 - ADL Model 6400
SENSOR NO.3 - Barnes Iris System
SENSOR NO.4 - Barnes Infralarm

LARGE TEMPERATURE CHAMBER (1)

CHAMBER TEMP. +25^{o}F
DATE 10/6/76

PATH NO.	SENSOR NO.1		SENSOR NO.2		SENSOR NO.3		SENSOR NO.4	
	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk
1	A		A		A		A	
2	A		A		A		A	
3	A		A		A		A	
4	A		A		A		A	
5	A		A		A		A	
6	A		A		A		A	
7	A		A		A		A	
8	A		A		A		A	
9	A		A		A		A	
10	A		A		A		A	
11	A		A		A		A	
12	A		NA		A		A	
13	A	A	NA	NA	A	A	A	A
14	A		NA		A		A	
15	A		NA		A		A	
16	A		NA		A		A	
17	A		NA		A		A	
18	A		NA		A		A	
19	A		A(9')		A		A	
20	A		A		A		A	
21	A		A(12')		A		A	
22	A		A		A		A	
23	A		A(12')		A		A	
24	A		A(9')		A		A	

EQUIPMENT TEMPERATURE (^{o}F)

THERMOCOUPLE NO.	START TEST	FINISH TEST
1	25.3	29.4
2	29.6	35.2
3	25.8	29.9
4	24.8	26.5
5	24.8	26.4
6	25.0	26.9
7	39.4	41.2
8	33.0	35.3
9	23.3	25.5
10	23.2	25.6

NOTES:
(1) H.E.T.C. Heavy Equipment Test Chamber
NA - No Alarm Traversing Entire Path
A - Sensor Alarm
SENSOR NO.1 - Barnes Infralarm
SENSOR NO.2 - ADL Model 6400
SENSOR NO.3 - Barnes Iris System
SENSOR NO.4 - Barnes Infralarm

LARGE TEMPERATURE CHAMBER (1)

CHAMBER TEMP. +50 °F
DATE 10/5/76

PATH NO.	SENSOR NO.1 slow walk	SENSOR NO.1 normal walk	SENSOR NO.2 slow walk	SENSOR NO.2 normal walk	SENSOR NO.3 slow walk	SENSOR NO.3 normal walk	SENSOR NO.4 slow walk	SENSOR NO.4 normal walk
1	A		A		A		A	
2	A		A		A		A	
3	A		A		A		A	
4	A		A		A		A	
5	A		A		A		A	
6	A		A		A		A	
7	A		A		A		A	
8	A		A		A		A	
9								
10	A		A		A		A	
11	A		A		A		A	
12	A	A	NA	NA	A	A	A	A
13	A	A	NA	A	A	A	A	A
14	A		NA		A		A	
15	A		NA		A		A	
16	A		NA		A		A	
17	A		NA		A		A	
18	A		NA		A		A	
19	A		A		A		A	
20	A		A		A		A	
21	A		A		A		A	
22	A		A		A		A	
23	A		A		A		A	
24	A		A		A		A	

EQUIPMENT TEMPERATURE (°F)

THERMOCOUPLE NO.	START TEST	FINISH TEST
1	50.5	51.9
2	55.1	56.9
3	51.1	52.3
4	49.5	50.5
5	49.5	50.4
6	49.7	50.8
7	68.5	68.8
8	61.0	61.1
9	48.4	47.3
10	48.4	41.0

NOTES:
(1) H.E.T.C. Heavy Equipment Test Chamber
NA - No Alarm Traversing Entire Path
A - Sensor Alarm
SENSOR NO.1 - Barnes Infralarm
SENSOR NO.2 - ADL Model 6400
SENSOR NO.3 - Barnes Iris System
SENSOR NO.4 - Barnes Infralarm

LARGE TEMPERATURE CHAMBER(1)

CHAMBER TEMP. +70 ^oF
DATE 10/6/76

PATH NO.	SENSOR NO.1		SENSOR NO.2		SENSOR NO.3		SENSOR NO.4	
	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk
1	A		A		A		A	
2	A		A		A		A	
3	A		A		A		A	
4	A		A		A		A	
5	A		A		A		A	
6	A		A		A		A	
7	A		A		A		A	
8	A		A		A		A	
9	A		A		A		A	
10	A		A	A	A		A	
11	A	A	NA	A	A	A	A	A
12	A	A	NA	A	A	A	A	A
13	A	A	NA	NA	A	A	A	A
14	A		NA		A		A	
15	A		NA		A		A	
16	A		NA		A		A	
17	A		NA		A		A	
18	A		NA		A		A	
19	A		A(8')		A		A	
20	A		A(9')		A		A	
21	A		A(12')		A		A	
22	A		A(8')		A		A	
23	A		A(6')		A		A	
24	A		A(9')		A		A	

EQUIPMENT TEMPERATURE (^oF)

THERMOCOUPLE NO.	START TEST	FINISH TEST
1	73.0	74.5
2	76.7	78.5
3	73.6	75.0
4	72.5	73.1
5	72.5	73.1
6	72.7	73.3
7	85.8	85.5
8	78.1	79.0
9	71.7	71.8
10	70.9	71.4

NOTES:
(1) H.E.T.C. Heavy Equipment Test Chamber
NA - No Alarm Traversing Entire Path
A - Sensor Alarm
SENSOR NO.1 - Barnes Infralarm
SENSOR NO.2 - ADL Model 6400
SENSOR NO.3 - Barnes Iris System
SENSOR NO.4 - Barnes Infralarm

LARGE TEMPERATURE CHAMBER(1)

CHAMBER TEMP. +98.6°F
DATE 10/7/76

PATH NO.	SENSOR NO.1		SENSOR NO.2		SENSOR NO.3		SENSOR NO.4	
	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk
1	NA	NA	NA	NA	A	NA	NA	NA
2	NA	NA	NA	NA	A	NA	NA	NA
3	A	A	NA	NA	A	A	A	A
4	A	A	NA	NA	A	A	A	A
5	A		NA		A		A	
6	A		NA		A		A	
7	A		NA		A		A	
8	A		NA		A		A	
9	A		NA		A		A	
10	A		NA		A		A	
11	A		NA		A		A	
12	A		NA		A		A	
13	A		NA		A		A	
14	A		NA		A		A	
15	NA	A	NA	NA	A	A	NA	A
16	NA	A	NA	NA	A	A	NA	A
17	NA	A	NA	NA	A	A	NA	A
18	A	A	NA	NA	A	A	NA	A
19	A	A	NA	NA	A	A	A	A
20	A	A	NA	NA	A	A	A	A
21	NA	NA	NA	NA	A	A	NA	A
22	NA	NA	NA	NA	NA	A	NA	NA
23	A	A	NA	A	A	A	NA	A
24	NA	A	NA	NA	A	A	NA	A

EQUIPMENT TEMPERATURE (^oF)

THERMOCOUPLE NO.	START TEST	FINISH TEST
1	100.5	103.2
2	103.2	105.7
3	100.9	102.7
4	99.3	100.0
5	99.3	100.0
6	99.5	100.2
7	112.7	113.8
8	106.0	107.2
9	98.3	98.9
10	98.2	98.1

NOTES:
(1) H.E.T.C. Heavy Equipment Test Chamber
NA - No Alarm Traversing Entire Path
A - Sensor Alarm
SENSOR NO.1 - Barnes Infralarm
SENSOR NO.2 - ADL Model 6400
SENSOR NO.3 - Barnes Iris System
SENSOR NO.4 - Barnes Infralarm

AD-A055 202 ARMY MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT COMM--ETC F/G 17/5
INFRARED MOTION SENSOR EVALUATION, (U)
MAR 78 W C GARRETT
UNCLASSIFIED MERADCOM-2237 NL

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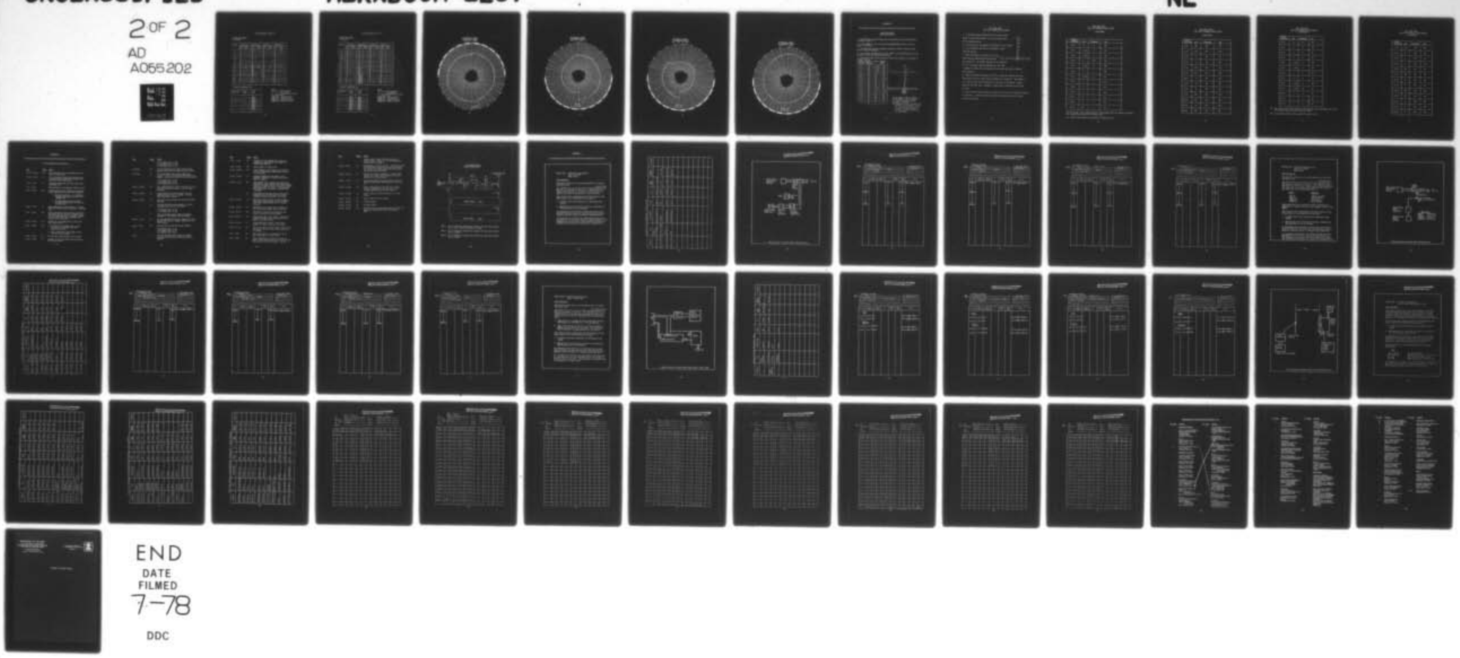

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DATE
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LARGE TEMPERATURE CHAMBER (1)

CHAMBER TEMP. +120 °F
DATE 10/4/76

PATH NO.	SENSOR NO.1 slow walk	SENSOR NO.1 normal walk	SENSOR NO.2 slow walk	SENSOR NO.2 normal walk	SENSOR NO.3 slow walk	SENSOR NO.3 normal walk	SENSOR NO.4 slow walk	SENSOR NO.4 normal walk
1	A	A	NA	A	A	A	A	NA
2	A		A		A		A	
3	A		A		A		A	
4	A		A		A		A	
5	A		A		A		A	
6	A		A		A		A	
7	A		A		A		A	
8	A		A		A		A	
9	A		A		A		A	
10	A		A		A		A	
11	A		A		A		A	
12	A	A	NA	A	A	A	A	A
13	A	A	NA	NA	A	A	A	A
14	A		NA		A		A	
15	A		NA		A		A	
16	A		NA		A		A	
17	A		NA		A		A	
18	A		NA		A		A	
19	A		A		A		A	
20	A		A		A		A	
21	A		A		A		A	
22	A		A		A		A	
23	A		A		A		A	
24	A		A		A		A	

EQUIPMENT TEMPERATURE (°F)

THERMOCOUPLE NO.	START TEST	FINISH TEST
1		123.8
2		127.5
3		125.4
4		121.8
5		121.9
6		122.1
7		135.1
8		127.8
9		120.3
10		119.2

NOTES:
(1) H.E.T.C. Heavy Equipment Test Chamber
NA - No Alarm Traversing Entire Path
A - Sensor Alarm
SENSOR NO.1 - Barnes Infralarm
SENSOR NO.2 - ADL Model 6400
SENSOR NO.3 - Barnes Iris System
SENSOR NO.4 - Barnes Infralarm

LARGE TEMPERATURE CHAMBER (1)

CHAMBER TEMP. +140 °F
DATE 10/7/76

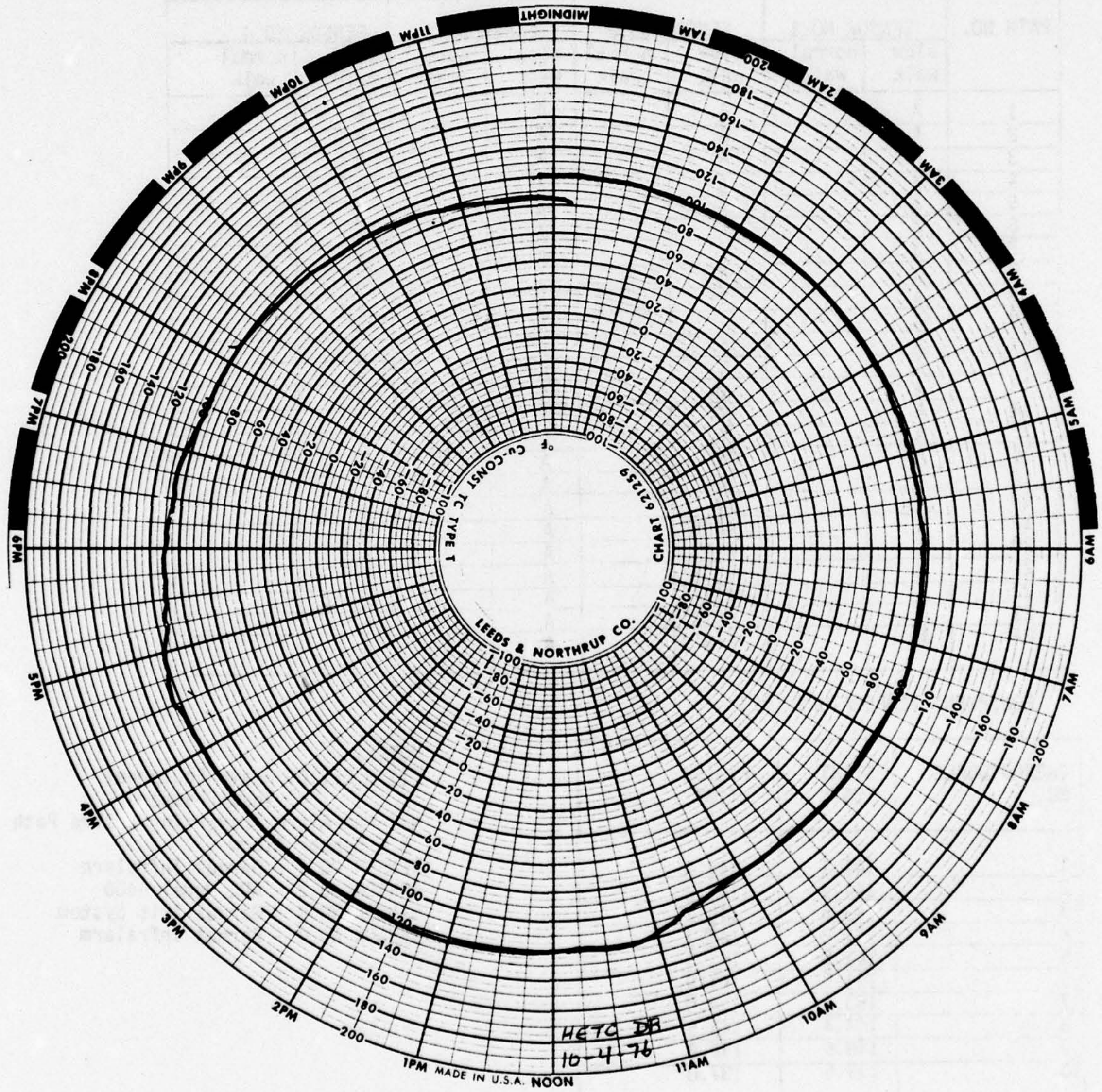
PATH NO.	SENSOR NO.1		SENSOR NO.2		SENSOR NO.3		SENSOR NO.4	
	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk	slow walk	normal walk
1	A		A		A		A	
2	A		A		A		A	
3	A		A		A		A	
4	A		A		A		A	
5	A		A		A		A	
6	A		A		A		A	
7	A		A		A		A	
8	A		A		A		A	
9	A		A		A		A	
10	A		A		A		A	
11	A		A		A		A	
12	A		A		A		A	
13	A		NA		A		A	
14	A		NA		A		A	
15	A		NA		A		A	
16	A		NA		A		A	
17	A		NA		A		A	
18	A		NA		A		A	
19	A		A(14')		A		A	
20	A		A(9')		A		A	
21	A		A(15')		A		A	
22	A		A(7')		A		A	
23	A		A(12')		A		A	
24	A		A(8')		A		A	

EQUIPMENT TEMPERATURE (°F)

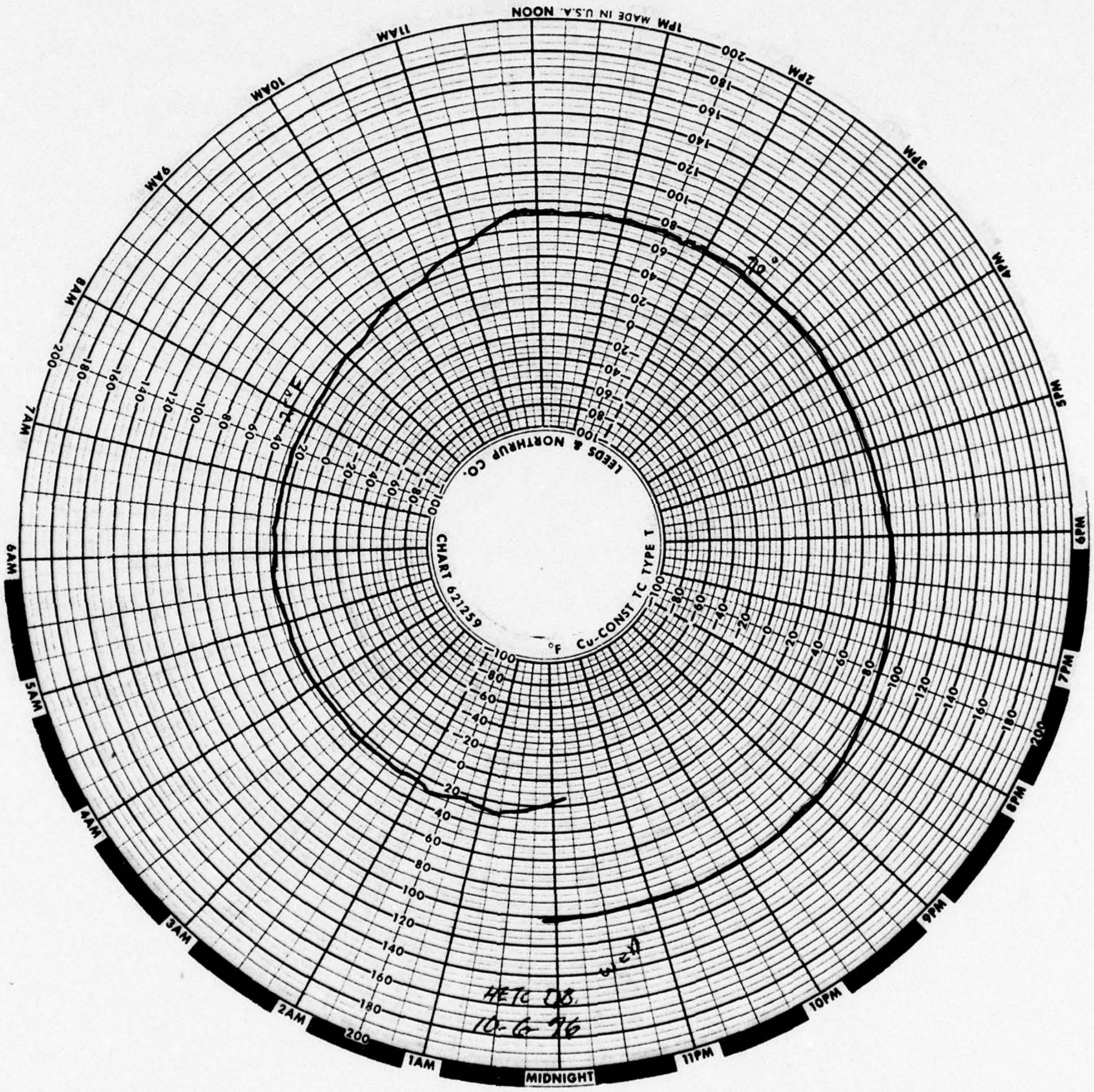
THERMOCOUPLE NO.	START TEST	FINISH TEST
1	144.1	144.3
2	144.9	146.2
3	143.8	145.2
4	141.8	141.7
5	141.9	141.8
6	141.9	141.9
7	153.5	154.0
8	144.4	145.5
9	140.6	139.8
10	139.5	137.8

NOTES:
(1) H.E.T.C. Heavy Equipment Test Chamber
NA - No Alarm Traversing Entire Path
A - Sensor Alarm
SENSOR NO.1 - Barnes Infralarm
SENSOR NO.2 - ADL Model 6400
SENSOR NO.3 - Barnes Iris System
SENSOR NO.4 - Barnes Infralarm

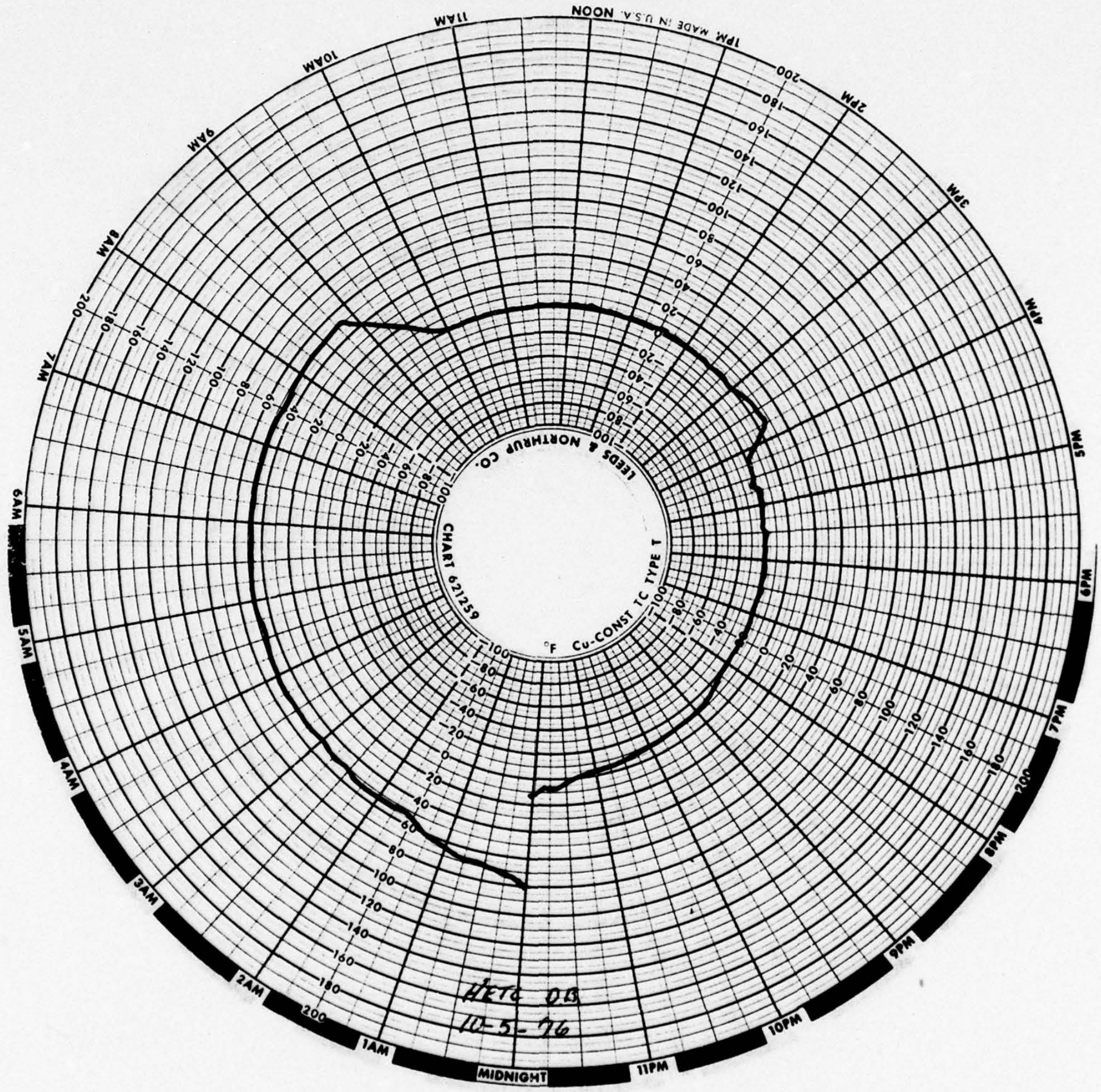
ENVIRONMENTAL CHAMBER
AIR TEMPERATURE RECORD
$98^{o}F$ & $120^{o}F$



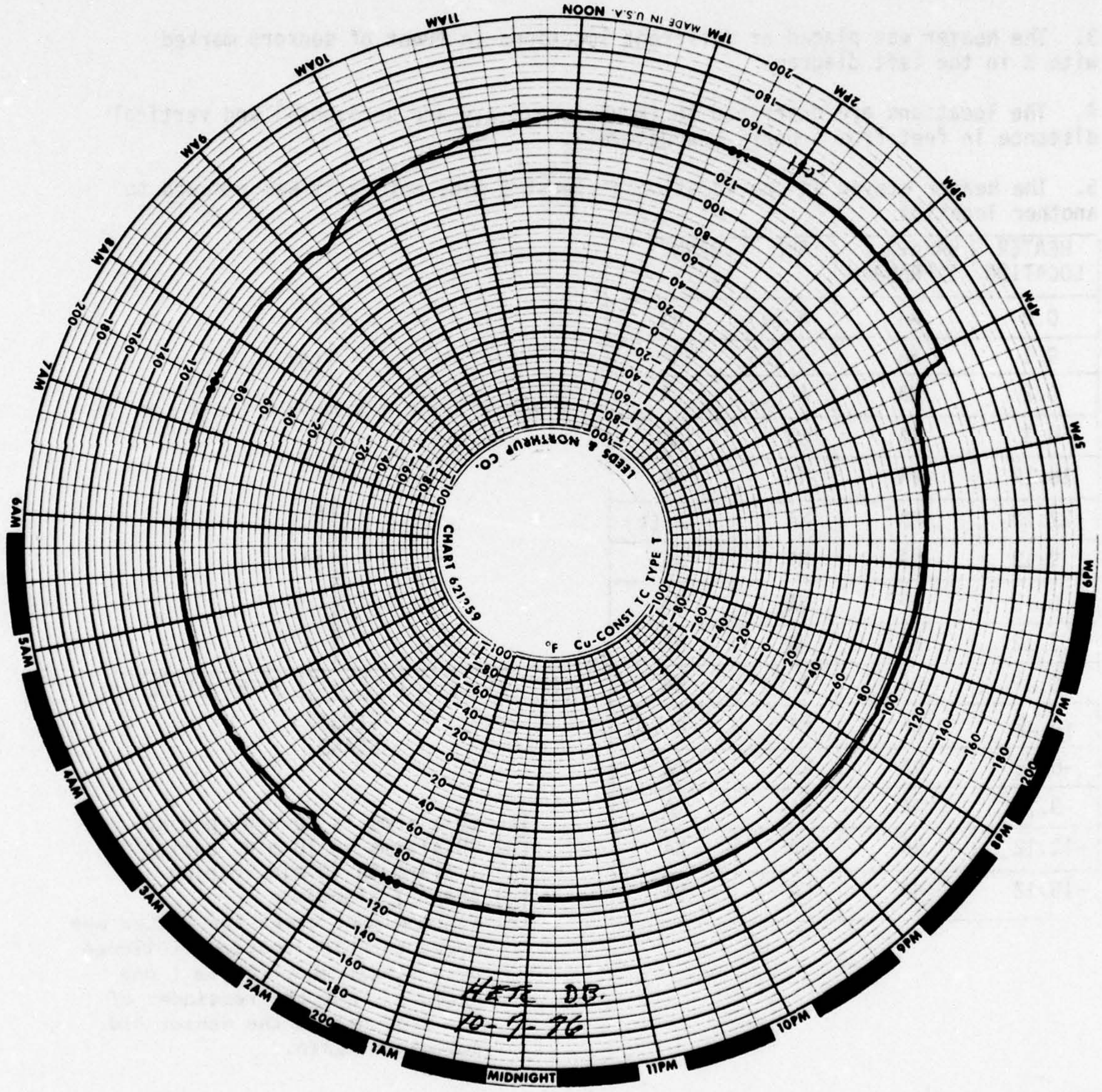
ENVIRONMENTAL CHAMBER
AIR TEMPERATURE RECORD
25°F & 70°F



ENVIRONMENTAL CHAMBER
AIR TEMPERATURE RECORD
50°F, 0°F & -20°F



ENVIRONMENTAL CHAMBER
AIR TEMPERATURE RECORD
98.6°F & 140°F



APPENDIX D

DATA SHEETS FOR TESTS CONVECTION HEATER AND PORTABLE SPACE HEATER

TEST DATA SHEET
CONVECTION HEATER

1. The 2250 watt convection heater was constructed with top and bottom open as shown in Figure

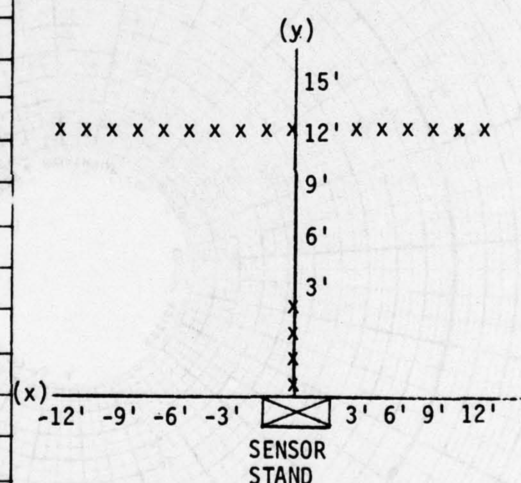
2. A mild steady hot air current will be produced about 30 min. after its power is turned on.

3. The heater was placed at different locations in front of sensors marked with X in the left diagram.

4. The locations are described in (x,y), where x,y are horizontal and vertical distance in feet from sensors respectively.

5. The heater stayed in one location at least 5 min. before it was removed to another location.

HEATER LOCATION	BARNES INFRALARM	ADL	BARNES IRIS
0.0	NA	A (a)	NA
0.1	NA	A (b)	NA
0.2	NA	A (c)	NA
0.3	NA	NA	NA
15.12	NA	NA	NA
12.12	NA	NA	A (e)
9.12	NA	NA	NA
6.12	NA	NA	NA
3.12	NA	NA	NA
0.12	NA	A (d)	NA
-3.12	NA	NA	A (e)
-6.12	NA	NA	NA
-9.12	NA	NA	NA
-12.12	NA	NA	NA
-15.12	NA	NA	NA

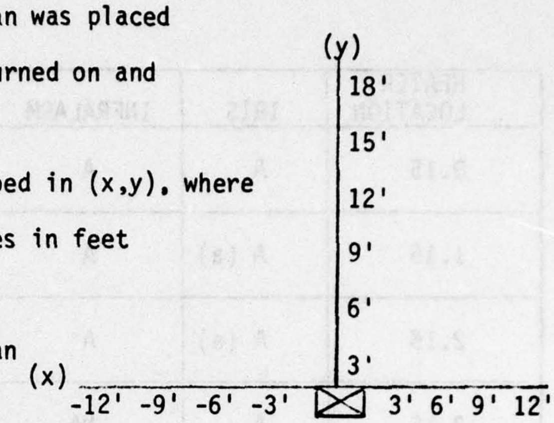


(a) 60 alarms in 10 min. period
(b) 30 alarms in 10 min. period
(c) 1 alarm in 10 min. period
(d) About 1 alarm/min.
(e) Alarmed once after the heater was moved to this location, followed by a single short alarm (one second). For the remainder of the test period the sensor did not alarm again.

TEST DATA SHEET
1650 WATT PORTABLE SPACE HEATER

1. A portable heater (1650 watt) with fan was placed about 4.5 feet above ground, it can be turned on and off by remote control.

2. The location of the heater is described in (x,y), where x, y are horizontal and vertical distances in feet from the sensors.



3. With the heater in location (6, 33) an IRIS alarm was generated when the heater was turned off. The heater had been on for durations of 8 to 23 seconds. Heater operation for less than 7 seconds or longer than 25 seconds will not cause the IRIS to alarm at this location.

4. When the heater was placed at (0.15) it caused the Infralarm and the IRIS sensors to alarm right after the heater was turned off. The heater in this case had been on for durations of 3 seconds to 20 seconds. Heater operation for less than 3 seconds or longer than 20 seconds did not cause an alarm.

5. Data in the following tables are results of the test at different locations of the heater. Alarms occurred right after the heater turned off unless otherwise specified.

TEST DATA SHEET
1650 WATT PORTABLE SPACE HEATER
(Continued)

HEATER LOCATION	IRIS	INFRALARM	ADL
0.15	A	A	NA
1.15	A (a)	A	NA
2.15	A (a)	A	NA
3.15	A	NA	NA
4.15	A (b)	A	NA
5.15	A	A	NA
6.15	A (a)	A	NA
7.15	A	A	NA
8.15	A	A	NA
9.15	A	A	NA
10.15	A	A	NA
11.15	A	A	NA
12.15	NA	A	NA

(a) Two alarms; first alarm occurred a few seconds after the heater was turned off, second alarm occurred 25 seconds later.

(b) Single alarm within a few seconds of heater turn on.

TEST DATA SHEET
1650 WATT PORTABLE SPACE HEATER

(Continued)

HEATER LOCATION	IRIS	INFRALARM	ADL
0.33	NA	NA	NA
1.33	NA	NA	NA
2.33	A	NA	NA
3.33	A	NA	NA
4.33	NA	NA	NA
5.33	NA	NA	NA
6.33	A	NA	NA
7.33	A	NA	NA
8.33	A	NA	NA
9.33	NA	NA	NA
10.33	NA	NA	NA
11.33	A	NA	NA
12.33	NA	NA	NA

TEST DATA SHEET
1650 WATT PORTABLE SPACE HEATER
(Continued)

HEATER LOCATION	IRIS	INFRALARM	ADL
0.15	A	A	NA
-1.15	A	A	NA
-2.15	A	A	NA
-3.15	A	A	NA
-4.15	A (b)	A	NA
-5.15	A (b)	A	NA
-6.15	A	A	NA
-7.15	A	A	NA
-8.15	A (b)	A	NA
-9.15	A (b)	NA	NA
-10.15	A	A	NA
-11.15	A	A	NA
-12.15	A	A	NA

(a) Two alarms; first alarm occurred a few seconds after the heater was turned off, second alarm occurred 25 seconds later.

(b) Single alarm within a few seconds of heater turn on.

TEST DATA SHEET
1650 WATT PORTABLE SPACE HEATER
(Continued)

HEATER LOCATION	IRIS	INFRALARM	ADL
0.33	NA	NA	NA
-1.33	A	NA	NA
-2.33	A	NA	NA
-3.33	A	NA	NA
-4.33	NA	NA	NA
-5.33	NA	NA	NA
-6.33	A	NA	NA
-7.33	A	NA	NA
-8.33	NA	NA	NA
-9.33	NA	NA	NA
-10.33	A	NA	NA
-11.33	A	NA	NA
-12.33	A	NA	NA

APPENDIX E

INFRARED SENSOR FALSE ALARM LOG AND IRIS ALARM DURATION IDENTIFICATION CIRCUIT

INFRARED SENSOR FALSE ALARM LOG

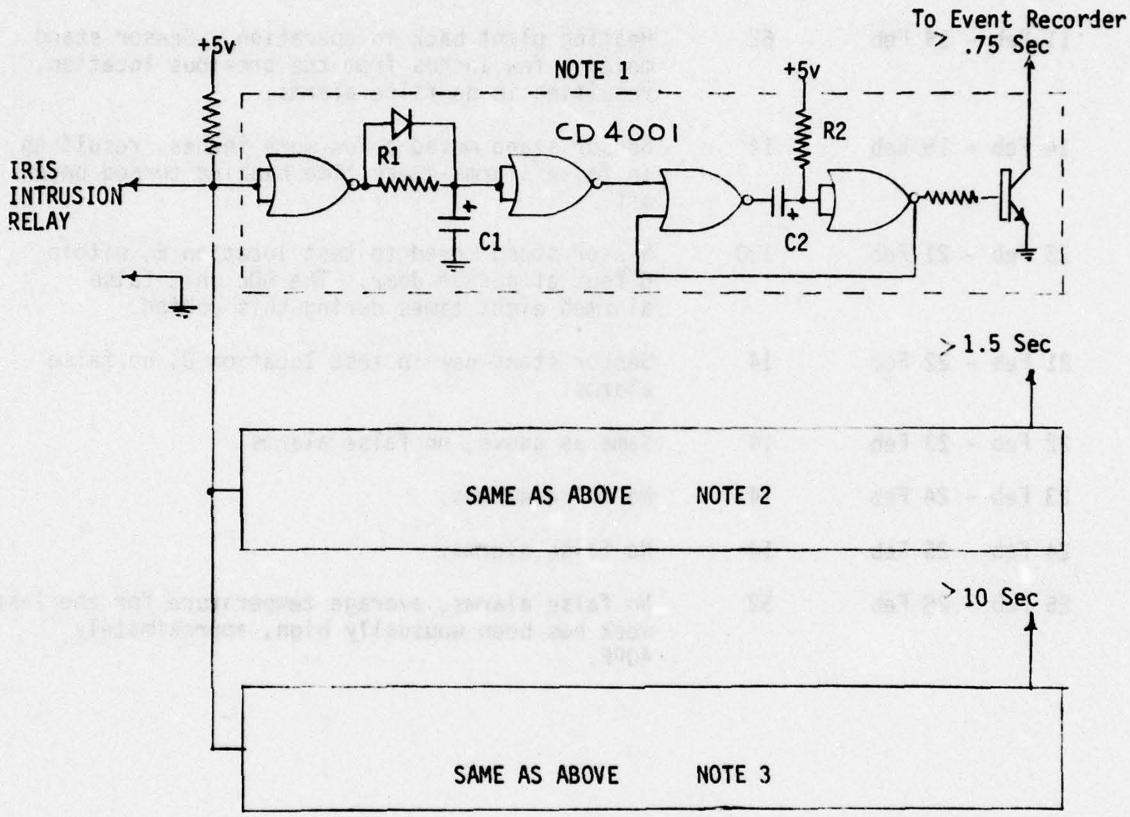
DATE	HOURS	NOTES
31 Jul - 20 Aug	316	IRIS operational, but not yet mounted on sensor stand, no false alarms.
21 Aug - 31 Aug	171	IRIS and commercial sensors now on sensor stand in test location A, during this period the IRIS generated a single false alarm.
1 Sep - 1 Oct	511	Single IRIS false alarm occurrred at 0530 hours, 4 September 1976.
2 Oct - 7 Oct		Moved equipment to environmental chamber for test.
8 Oct - 25 Oct	280	Installed sensors in test location B. Convection heater added to maintain 120°F room temperature. a. The ADL unit alarmed once at 2300 hours, 8 October 1976 and again at 0600 hours, 9 October 1976. b. The IRIS alarmed once at 0100 hours, 11 October 1976 and again at 1100 hours, 15 October 1976.
26 Oct - 1 Nov	97	Sensor stand moved to test location C, a single IRIS false alarm occurred at 1600 hours, 31 October 1976.
1 Nov - 17 Nov	287	Sensor stand moved to test location D, during the time period 0300 to 0730 hours, 8 November 1976, the IRIS alarmed once every 7.5 minutes. Capping all IRIS sensor heads until 16 November 1976 resulted in no false alarms.
18 Nov - 23 Nov	110	At 0500 hours, 23 November 1976, a single IRIS false alarm occurred.
24 Nov - 17 Dec	453	A. At 0630 hours, 6 December 1976, a single IRIS false alarm occurred, the room temperature was 62°F. B. IRIS alarm duration circuit added to false alarm monitoring equipment.
17 Dec - 20 Dec	63	All IRIS sensor heads capped, no false alarms.
20 Dec - 21 Dec	19	Uncapped all eight IRIS sensor heads resulting in the following alarms.

DATE	HOURS	NOTES
		10 FA greater than .75 sec 2 FA greater than 1.5 sec 18 FA greater than 10 sec
21-22 Dec	18	All cart mounted sensor heads capped, stand mounted IRIS sensors uncapped, no false alarms.
22-23 Dec	17	All stand mounted IRIS sensors capped and number 4, 8 and 6 cart mounted IRIS sensors uncapped. During this period false alarms occurred: 2 FA greater than .75 sec 3 FA greater than 1.5 sec 16 FA greater than 10 sec
23 Dec - 27 Dec	90	At a room temperature of 55°F, and with all cart mounted IRIS sensors capped, no false alarms occurred.
27 Dec - 28 Dec	16	Stand mounted IRIS sensors capped, and cart mounted sensors 7 and 9 uncapped. A single IRIS false alarm occurred.
28 Dec - 30 Dec	14	Same test as above except two IRIS false alarms occurred.
	16	Cart mounted IRIS sensors numbers 4, 8 and 6 uncapped, resulting in false alarms: 7 FA greater than .75 sec 31 FA greater than 10 sec
	7	IRIS cart mounted sensor number 4 uncapped, resulted in 3 FA greater than 10 seconds.
30 Dec - 3 Jan	87	All cart mounted IRIS sensors capped, all stand mounted IRIS sensors uncapped, resulting in no false alarms.
3 Jan - 5 Jan	28	Uncapped cart mounted IRIS sensor number 8. 9 FA greater than .75 sec 8 FA greater than 1.5 sec 5 FA greater than 10 sec
5 Jan	3	IRIS cart mounted sensor number 6 uncapped, resulting in one false alarm greater than 10 seconds.

DATE	HOURS	NOTES
5 Jan - 7 Jan	38	Recapped all cart mounted IRIS sensors and uncapped all stand mounted IRIS sensors, no false alarms resulted.
7 Jan - 10 Jan	64	Same as above, no false alarms.
12 Jan - 13 Jan	14	Large cardboard shield placed on top of IRIS cart, all IRIS sensors capped except number 8, no false alarms.
13 Jan - 14 Jan	14	Cardboard removed and IRIS number 8 still uncapped, resulting in 8 false alarms greater than 1.5 seconds.
14 Jan - 17 Jan	42	IRIS number 8 still uncapped, and foam blocks added to four sides (field of view unobstructed) resulting in greater than 50 false alarms randomly spaced during the time period. Alarm durations from greater than .75 seconds to greater than 10 seconds.
	20	Continuation of the above test, alarm rate has increased on the IRIS substantially to many hundreds of alarms during this time period.
17 Jan - 18 Jan	14	Foam block placed in field of view of number 8 IRIS sensor, approximately 4 inches from lens. Seven false alarms greater than 1.5 seconds occurred.
18 Jan - 19 Jan	14	Continuation of the above test resulted in 10 IRIS false alarms greater than 1.5 seconds.
21 Jan - 24 Jan	60	IRIS number 8 completely surrounded by foam blocks, resulting in no false alarms.
24 Jan - 25 Jan	14	Stand mounted IRIS sensor number 5 lowered and mounted on tripod at the same height as IRIS number 8, no false alarms.
26 Jan - 27 Jan	14	Located IRIS sensor number 5 under heating register (9 feet), resulting in 53 alarms.
28 Jan - 31 Jan	60	IRIS sensor number 5 facing forward, (location D), resulting in two IRIS false alarms greater than .75 seconds.
3 Feb - 4 Feb	14	IRIS sensor number 5 on tripod facing garage door, resulting in no false alarms.
4 Feb - 7 Feb	60	Sensor stand moved to location E, facing the heating plant, resulting in periodic false alarms occurring during the time period. The time

DATE	HOURS	NOTES
		between alarms varied from four minutes to thirty minutes. Almost all of the alarms were greater than 10 seconds.
8 Feb - 9 Feb	14	Continuation of the above test. The heating plant failed two hours after the building was vacated. The IRIS did not alarm again until the building was entered the next morning.
11 Feb - 14 Feb	62	Heating plant back in operation. Sensor stand moved a few inches from the previous location, resulting in no false alarms.
14 Feb - 15 Feb	14	Sensor stand moved a few more inches, resulting in false alarms every time heating turned on or off.
15 Feb - 21 Feb	130	Sensor stand moved to test location E, within 6 feet of garage door. The ADL unit false alarmed eight times during this period.
21 Feb - 22 Feb	14	Sensor stand now in test location D, no false alarms.
22 Feb - 23 Feb	14	Same as above, no false alarms.
23 Feb - 24 Feb	14	No false alarms.
24 Feb - 25 Feb	14	No false alarms.
25 Feb - 28 Feb	52	No false alarms, average temperature for the last week has been unusually high, approximately 40°F.

IRIS ALARM DURATION
IDENTIFICATION CIRCUIT



NOTE 1 - R1 & C1 selected to enable event recorder for alarm inputs greater than .75 sec. R2 & C2 selected for 1 second.

NOTE 2 - R1 & C1 selected to enable event recorder for alarm inputs greater than 1.5 seconds.

NOTE 3 - R1 & C1 selected to enable event recorder for alarm inputs greater than 10 seconds.

APPENDIX F

ELECTROMAGNETIC INTERFERENCE TEST PROCEDURES AND DATA SHEETS

Method CS01 - Conducted Susceptibility
30 Hz to 50 kHz
Power lines

Test Procedure

The security system was set up and operated in its normal functional mode.

The CS01 test was performed on the 115 Vac side of the transformer which was set up as depicted on Figure 1. A voltage level of 3 volts rms was applied to the 115 volt line from 30 Hz to 1500 Hz and gradually decreased to 1 volt at 50 kHz.

The criteria used in determining the effectiveness of the alarm system to the susceptibility test were -

1. A single false alarm indication or continuous false alarms.

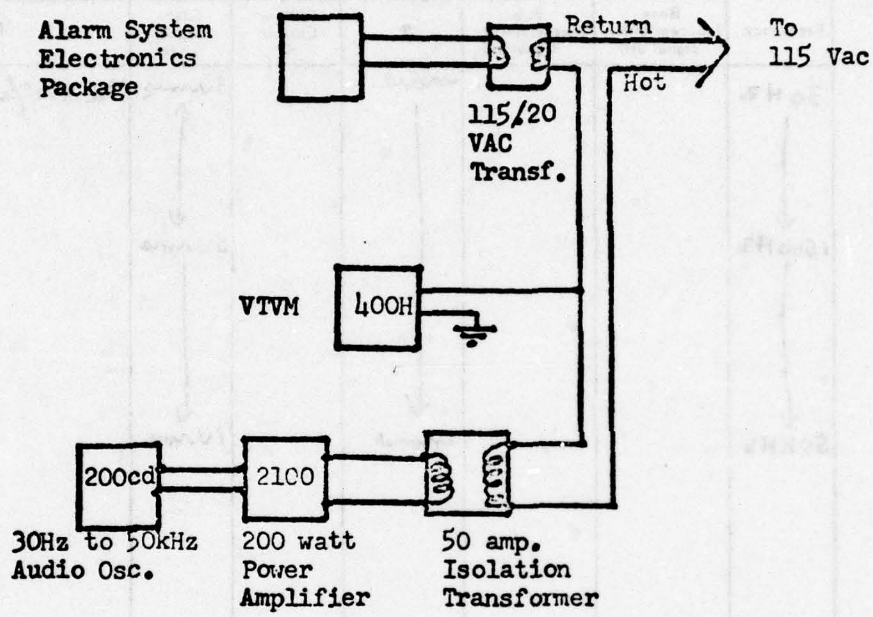
2. Malfunction of the detection circuits as evidenced by the non-detection of an intruder.

To accommodate both conditions a person was used to walk thru the effective beam area while the test was being performed to determine normal or abnormal system operation.

If a response was observed, the induced voltage level was decreased until the system returned to normal operation. The frequency and voltage level of the interfering signal are recorded and represents the threshold of susceptibility.

Equipment List for Method CS01 - 30 Hz to 50 kHz

FREQUENCY	ITEM	MANUFACTURER	MODEL	S/N	CAL. PERIOD	DATE OF LAST CAL.	ACCURACY
30 Hz to 250 kHz	Audio Isolation Transformer	Solar Electronics	6220-1A	TI-3750-1	2 required	-	
30 Hz to 250 kHz	Amplifier-200W	McIntosh	2100	TI-4375-1	1 year	Aug. 1976	
5 Hz to 600 kHz	Audio Oscillator	Hewlett-Packard	200 cd	TI-473-23	6 months	Apr/Sep 1976	
10 Hz - 4 MHz	VTVM	Hewlett-Packard	400 H	TI-123-11	1 year	May 1976	



Typical Setup for Method CS01, Conducted Susc.

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#11

SUSCEPTIBILITY TEST DATA

Test Item BARNES #1 S/N ______ Date 21 SEP. 1976
Test Performed COND. SUSC. By SCALSKY
Spec. MIL-Std-461A Para. CS01 Appr. By ______
Lead(s) Tested 115 VAC Witness ______
Transducer ______ Sheet ____ of ______
Critical Points Monitored ______ with ______

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
30 HZ ↓			none ↓		3 vrms ↕	No malfunctions
1500 HZ ↓					3 vrms ↓	
50 KHZ			none		1 vrms	

#12

SUSCEPTIBILITY TEST DATA

Test Item BARNES #2 S/N ______ Date 21 SEP. 1976
Test Performed COND. SUSC ______ By SCALSKY
Spec. MIL-Std-461A Para. CS01 Appr. By ______
Lead(s) Tested 115 VAC Witness ______
Transducer ______ Sheet ___ of ___
Critical Points Monitored ______ with ______

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
30Hz			none		3vrms	No malfunctions
1500Hz					3vrms	
50kHz			none		1vrms	

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SUSCEPTIBILITY TEST DATA

#13

Test Item ADL- INSIDE S/N RECEIVER Date 21 SEP. 1976

Test Performed COND. SUSC. By SCALSKY

Spec. MIL-STD-461A Para. CS01 Appr. By

Lead(s) Tested 115 VAC Witness

Transducer Sheet of

Critical Points Monitored with

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
30 Hz			none		3 vrms	no malfunctions
1500 Hz					3 vrms	
50 KHz			none		1 vrms	

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#14

SUSCEPTIBILITY TEST DATA

Test Item IRIS S/N ______ Date 21 SEP. 1976

Test Performed Cond. Susc. By SCALSKY

Spec. MIL-Std-461A Para. CS01 Appr. By ______

Lead(s) Tested 115VAC Witness ______

Transducer ______ Sheet ___ of ___

Critical Points Monitored ______ with ______

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
30Hz			none		3vrms	No malfunctions
↓			↓		↓	
1500Hz					3vrms	
↓			↓		↓	
50KHz			none		1vrms	

Method CS02 - Conducted Susceptibility
50 kHz to 400 MHz
Power lines

Test Procedures

The security system was set up and operated in its normal functional mode. The CS02 test was performed on the 115 Vac side of the transformer which was set up as depicted on Figure 2. The frequency range from 50 kHz to 400 MHz was scanned using an applied voltage of 1 volt rms. The signals were injected on the 115 Vac hot lead using the following capacitors -

Value	Frequency
.68 μfd	.050 to 0.50 MHz
.068 μfd	.50 to 5.0 MHz
.0068 μfd	5 to 50 MHz
.00068 μfd	50 to 400 MHz

These capacitors were selected in order to maintain an impedance of 5 ohms or less over the frequency range listed above.

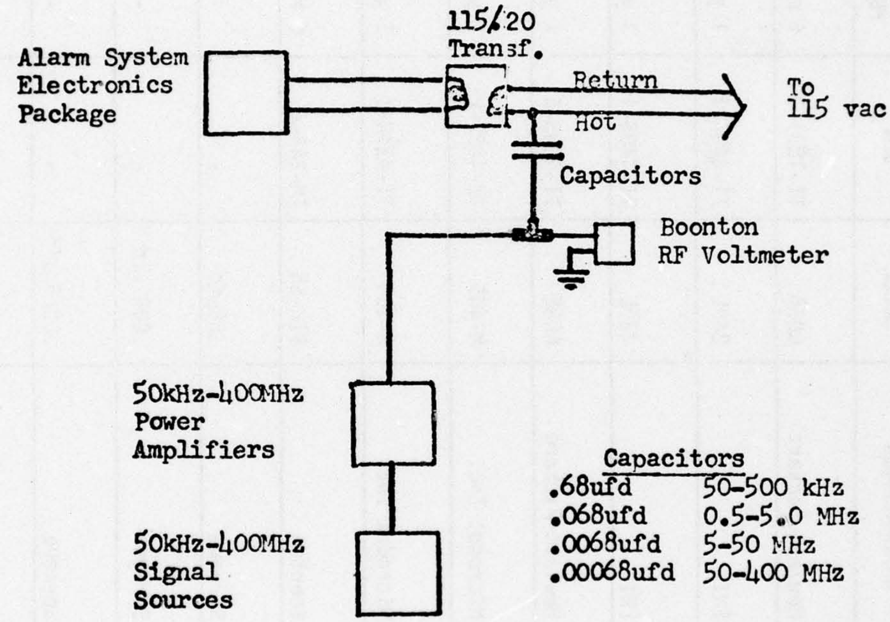
The criteria used in determining the effectiveness of the alarm system to the susceptibility test were -

1. A single false alarm indication or continuous false alarms.

2. Malfunction of the detection circuits as evidenced by the non-detection of an intruder.

To accommodate both conditions a person was used to walk thru the effective beam areas while the test was being performed to determine normal or abnormal system operation.

If a response was observed, the induced voltage level was decreased until the system returned to normal operation. The frequency and voltage level of the interfering signal are recorded and represents the threshold of susceptibility.



Typical Setup for Method CS02, Conducted Susc.

Test Equipment List for Method CS02 - 50 Hz to 400 MHz

FREQUENCY	ITEM	MANUFACTURER	MODEL	S/N	CAL. PERIOD	DATE OF LAST CAL.	ACCURACY
50 kHz - 65 MHz	Signal Generator	Hewlett-Packard	606A	TI-1881-3	6 months	Apr. 1976	
20 kHz - 10 MHz	RF Power Amplifier	ENI	240L	TI-4404-1	1 year	Aug. 1976	
.15-250 MHz	RF Power Amplifer	ENI	420L	TI-4405-1	1 year	Aug. 1976	
10-480 MHz	VHF Signal Generator	Hewlett-Packard	608E	TI-4083-6	1 year	Apr. 1976	
10-2000 MHz	RF Power Oscillator	Microdot Inc.	M-445	TI-4337-2	1 year	Apr. 1976	
200-500 MHz	Plug-in	Microdot Inc.	M-186	TI-4340-1	1 year	Nov. 1975	
20 kHz-1200 MHz	RF Voltmeter	Boonton	91H-S5	TM-244-6	[illegible] months	May 1976	
050-.50 MHz	Capacitor	Sprague	.68μfd	-	-	-	
0.5 - 5.0 MHz	Capacitor	Sprague	.068 μfd	-	-	-	
5.0 - 50 MHz	Capacitor	Sprague	.0068 μfd	-	-	-	
50 - 400 MHz	Capacitor	Sprague	.00068 μfd	-	-	-	

#11

SUSCEPTIBILITY TEST DATA

Test Item BARNES #1 S/N ______ Date 21 SEP. 1976
Test Performed COND. SUSC. By SCALSKY
Spec. MIL-Std.-461A Para. CS02 Appr. By ______
Lead(s) Tested 115VAC, HOT Witness ______
Transducer ______ Sheet ___ of ___
Critical Points Monitored ______ with ______

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
50KHz			none		1vrms	No malfunctions
↓			↕		↕	
400MHz			none		1vrms	

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SUSCEPTIBILITY TEST DATA

#12

Test Item BARNES #2 S/N ________ Date 21 SEP 1976

Test Performed COND. SUSC. By SCALSKY

Spec. MIL-Std-461A Para. CS02 Appr. By ________

Lead(s) Tested 115 VAC, HOT Witness ________

Transducer ________ Sheet ____ of ________

Critical Points Monitored ________ with ________

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
50KHz			none		1vrms	No malfunctions
↓			↓		↓	
400MHz			none		1vrms	

SUSCEPTIBILITY TEST DATA

#13 Test Item ADL-INSIDE S/N RECEIVER Date 21 SEP. 1976
Test Performed COND. SUSC. By SCALSKY
Spec. MIL-Std-461A Para. CS02 Appr. By
Lead(s) Tested 115VAC, HOT Witness
Transducer Sheet ___ of ___
Critical Points Monitored ___ with ___

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
50KHz			none		1Vrms	No malfunctions
↓			↓		↕	
400MHz			none		1Vrms	

SUSCEPTIBILITY TEST DATA

#14

Test Item IRIS S/N ______ Date 21 SEP. 1976
Test Performed COND. SUSC. By SCALSKY
Spec. MIL-Std.-461A Para. CS02 Appr. By ______
Lead(s) Tested 115VAC, HOT Witness ______
Transducer ______ Sheet ___ of ___
Critical Points Monitored ______ with ______

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
50KHz			none		1Vrms	No malfunctions
400MHz			none		1Vrms	

Method CS06 - Conducted Susceptibility
Spike - Power Lines

Test Procedures

The security system was set up and operated in its normal functional mode.

The CS06 test was performed on the 115 Vac side of the transformer which was set up as depicted in Figure 3. The injected spike has a fixed width of 10 μ seconds and was applied via series injection to the 115 Vac hot lead under the following conditions -

1. Application of a random 100 volts spike both positive and negative at the rates of 1, 10, and 500 pps.

2. Sync condition using 100 volt positive and negative spikes at each 90^{o} of the sine wave. All conditions were maintained for approximately one minute each.

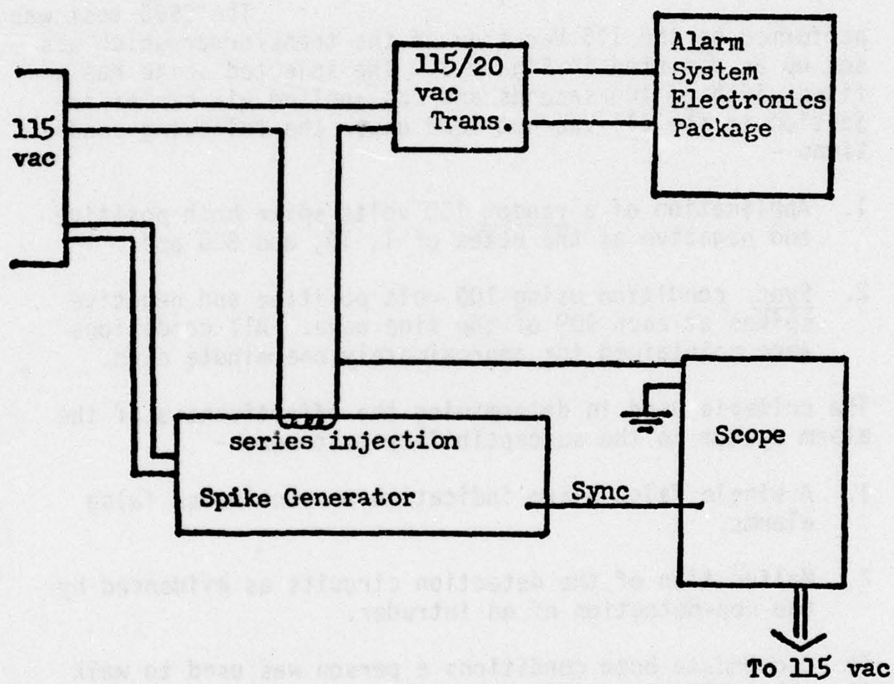
The criteria used in determining the effectiveness of the alarm system to the susceptibility test were -

1. A single false alarm indication or continuous false alarms.

2. Malfunction of the detection circuits as evidenced by the non-detection of an intruder.

To accommodate both conditions a person was used to walk thru the effective beam area while the test was being performed to determine normal or abnormal system operation.

If a response was observed, the amplitude of the spike and/or the repetition rate was decreased until the system returned to normal operation. The threshold of susceptibility was recorded on the data sheets.



Typical Setup for Method CS06, Spike Susc.- Power Leads

Equipment List for Method CS06 - Spike

FREQUENCY	ITEM	MANUFACTURER	MODEL	S/N	CAL. PERIOD	DATE OF LAST CAL.	ACCURACY
--	Spike Generator	Honeywell	4881	TI-4069	Cal during use		
	Oscilloscope	Tekronix	545-B	TI-4064-1	1 year	May 1976	
Verify Pulse Only	Resistor	5 ohm	--	--	--	--	
	Isolation Transformer	Stancor	5 amp	--	--	--	

#11

SUSCEPTIBILITY TEST DATA

Test Item Barnes #1 S/N ____ Date 21 SEP. 1976
Test Performed Cond. Susc By Scalsky
Spec. Mil-Std.-461A Para. CS06 - SPIKE Appr. By ____
Lead(s) Tested 115 VAC Witness ____
Transducer ____ Sheet ____ of ____
Critical Points Monitored ____ with ____

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
Sync						
+100V	0, 90°, 270°					No malfunctions
-100V	0, 90°, 270°					No malfunctions
Random						
+100V	1, 10, 500 pps					No malfunctions
-100V	1, 10, 500 pps					No malfunctions

#2

SUSCEPTIBILITY TEST DATA

Test Item BARNES #2 S/N ______ Date 21 SEPT. 1976

Test Performed COND SUSC. By SCALSKY

Spec. MIL-STD-461A Para. CS06 - SPIKE Appr. By ______

Lead(s) Tested 115 VAC Witness ______

Transducer ______ Sheet ___ of ___

Critical Points Monitored ______ with ______

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
SYNC						
+100V	0, 90°, 270°					No malfunctions
-100V	0, 90°, 270°					No malfunctions
RANDOM						
+100V	1, 10, 500 pps					No malfunctions
-100V	1, 10, 500 pps					No malfunctions

SUSCEPTIBILITY TEST DATA

#13 Test Item ADL INSIDE S/N RECEIVER Date 21 SEP. 1976

Test Performed CONDUCTED SUSC By SCALSKY

Spec. MIL-STD 461A Para. CS06 - SPIKE Appr. By

Lead(s) Tested 115VAC Witness

Transducer Sheet of

Critical Points Monitored with

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
Sync						
+100V	0, 90°, 270°					No malfunctions
-100V	0, 90°, 270°					No malfunctions
Random						
+100V	1, 10, 500 PPS					No malfunctions
-100V	1, 10, 500 PPS					No malfunctions

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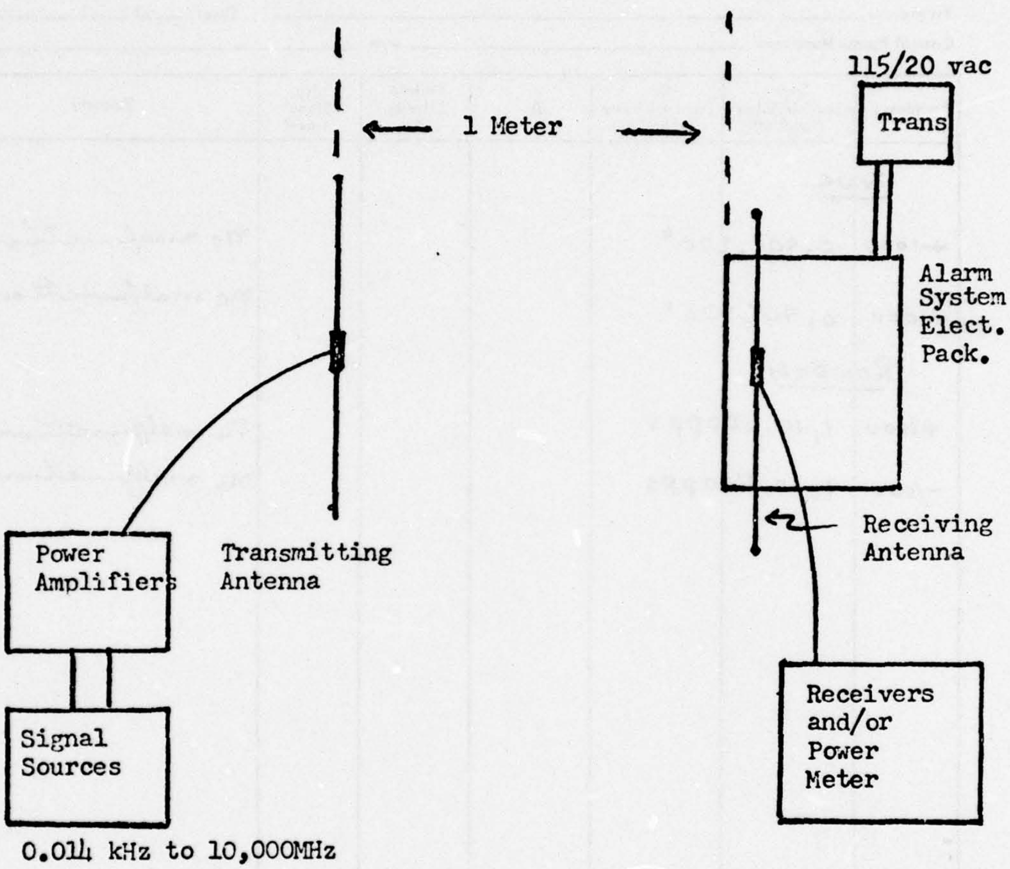
#14

SUSCEPTIBILITY TEST DATA

Test Item IRIS S/N ____ Date 21 SEP 1976
Test Performed Cond Susc By Schlisky
Spec. MIL-Std-461A Para. CS06-Spike Appr. By ____
Lead(s) Tested ____ Witness ____
Transducer ____ Sheet ____ of ____
Critical Points Monitored ____ with ____

Frequency	Base (susceptibility signal off)	Run (susceptibility signal on)	Δ	Failure Criteria ≤	Susc. Signal Level	Remarks
	SYNC					
+100V	0, 90°, 270°					No malfunctions
-100V	0, 90°, 270°					No malfunctions
	RANDOM					
+100V	1, 10, 500pps					No malfunctions
-100V	1, 10, 500pps					No malfunctions



Typical Setup for Method RS03, E Field Radiated Susc.

Method RS03 - Radiated Susceptibility
.014 to 10,000 MHz Electric Field

Test Procedure

The security system was set up and operated in its normal functional mode. Antennas were set up one meter from the system's electronics package. Measurement of the field intensity value were accommodated by placing a receiving antenna in the approximate location of the electronic package.

The criteria used in determining the effectiveness of the alarm system to the susceptibility test were -

1. A single false alarm indication or continuous false alarms.

2. Malfunction of the detection circuits as evidenced by the non-detection of an intruder.

To accommodate both conditions a person was used to walk through the effective beam area while the test was being performed. The person was far away from the radiating antenna to prevent affecting the radiated field.

The radiated fields were accompanied by the following modulations -

Freq.	
.014 - 30 MHz	50% AM at 1000 Hz
30 - 2000 MHz	100% square wave at 1000 Hz rate
2-4 GHz	10 μs pulse at 1000 Hz rate
4-11 GHz	100% square wave at 1000 Hz rate

If a response was observed, the field intensity was decreased until the system returned to normal operation. The threshold of susceptibility was recorded on the data sheets.

Test Equipment List for Method RS03 - Radiated Susceptibility - .014 - 10,000 MHz

FREQUENCY	ITEM	MANUFACTURER	MODEL	S/N	CAL. PERIOD	DATE OF LAST CAL.	ACCURACY
.014-1000MHz	RFI Meter	Singer Metrics	NF-105	TI-1278-1	6 months	Apr. 1976	
.014-.15 MHz	Tuning Unit	Singer Metrics	TX/NF-105	TI-3756-1	6 months	Apr. 1976	
.15- 30 MHz	Tuning Unit	Singer Metrics	TA/NF-105	TI-2179-1	6 months	Apr. 1976	
20-200 MHz	Tuning Unit	Singer Metrics	T1/NH-105	TI-1630-1	6 months	Apr. 1976	
200-400 MHz	Tuning Unit	Singer Metrics	12/NF-105	TI-1632-1	6 months	Apr. 1976	
400-1000 MHz	Tuning Unit	Singer Metrics	T3/NF-105	TI-1634-1	6 months	Apr. 1976	
1 kHz - 60 MHz	Active Rod Antenna	ARA	AVW-2/D	T1-4388-1A	Man. Cal.	-	
20-200 MHz	Antenna Dipole	Singer Metrics	MD-105-T1	TI-1631-2	Man. Cal.	-	
200-400 MHz	Antenna Tuned Dipole	Singer Metrics	MD-105-T2	TI-1633-2	Man. Cal.	-	
200-1000 MHz	Antenna Tuned Dipole	Singer Metrics	MD-105-T3	TI-1635-2	Man. Cal.	-	
.014-30 MHz	Parallel Plate Antenna	WEI	401	TI-4345-1	NCR	-	
5 Hz - 600 kHz	Audio Oscillator	Hewlett-Packard	200 cd	TI-473-1	1 year	Apr/Sep 1976	

(Con't) Test Equipment List for Method RS03- Radiated Susc. .014 - 10,000 MHz

FREQUENCY	ITEM	MANUFACTURER	MODEL	S/N	CAL. PERIOD	DATE OF LAST CAL.	ACCURACY
20 Hz-200 kHz	Audio Amplifier	McIntosh	M2100	TI-4375-1	1 year	Aug. 1976	
50 kHz-65 MHz	HF Signal Generator	Hewlett-Packard	606A	TI-1881-11	1 year	Apr. 1976	
1.8-4.2 GHz	UHF Signal Generator	Hewlett-Packard	616A	TI-60-27	1 year	July 1976	
3.8 - 7.6 GHz	SHF Signal Generator	Hewlett-Packard	618B	TI-133-5	1 year	Apr. 1976	
7-11 GHz	SHF Signal Generator	Hewlett-Packard	620A	TI-2095-2	1 year	Jun. 1976	
1.0 - 2.24 GHz	Antenna	Polarad	CA-L	TI-2136-1G	Man. Cal.		
2.14-4.34	Antenna	Polarad	CA-S	TI-2136-1H	Man. Cal.		
4.2 - 7.74 GHz	Antenna	Polarad	CA-M	TI-2136-1J	Man. Cal.		
-.36-10 GHz	Antenna	Polarad	CA-X	TI-2136-1K	Man. Cal.		
0-18 GHz	Spectrum Analyzer	Hewlett-Packard	141T	TI-4184-1	1 year	Aug. 1976	
	RF Section	Hewlett-Packard	8555A	TI-4461-3	1 year	July 1976	
	IF Section	Hewlett-Packard	8552B	TI-4186-8	1 year	Aug. 1976	

(Con't) Test Equipment List for Method RS03 - Radiated Susc. - .014 to 10,000 MHz

FREQUENCY	ITEM	MANUFACTURER	MODEL	S/N	CAL. PERIOD	DATE OF LAST CAL.	ACCURACY
10-2000 MHz	Power Oscillator	Microdot, Inc.	M445	TI-4377-2	1 year	Apr. 1976	
10-50 MHz	Plug-In	Microdot, Inc.	M184	TI-4338-1	1 year	Apr. 1976	
50-200 MHz	Plug-in	Microdot, Inc.	M185	TI-4339-1	1 year	Apr. 1976	
200-500 MHz	Plug-in	Microdot, Inc.	M186	TI-4340-1	1 year	Nov. 1975	
500-1000 MHz	Plug-in	Microdot, Inc.	M187	TI-9718-1	1 year	Apr. 1976	
1000-2000 MHz	Plug-in	Microdot, Inc.	188A	TI-4515-1	1 year	Apr. 1976	
20 kHz-10 MHz	RF Power Amplifier	ENI	240L	TI-4404-1	1 year	Aug. 1976	
150kHz-250 MHz	RF Power Amplifier	ENI	420L	TI-4405-1	1 year	Aug. 1976	
2-4 GHz	TWT Amplifier	Hughes	1177 H01	TI-4512-1	6 months	May 1976	
4-10.5 GHz	TWT Amplifier	Hughes	1177H06	TI-4513-1	6 months	May 1976	
10 MHz-10GHz	Power Meter	Hewlett-Packard	432A	TI-4121-2	6 months	Sept. 1976	

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Fort Belvoir

Test	RS03 - Radiated Susc.	Date	28 Sept. 1976
Manufacturer	Barnes #1	Task No.	6072.00100
Item #11	Alarm	Operator	Scalsky
MOD/S.N.		Equipment	

FREQ. MHz	MEAS. dBm	EQUIV. dBuV	ATTEN dB	ANT. FACTOR dB	TOTAL dBuV/m	TOTAL V/m		Remarks
.014			0		140	10.		No malfunctions
								"
								"
30			0		140	10		"
30			0		134	5		"
								"
								"
1000			0		134	5		"

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Fort Belvoir

Test	RS03 - Radiated Susc.	Date	22 Sept 1976
Manufacturer	Barnes #1	Task No.	6073.05100
Item	#11 Alarm	Operator	Scalsky
MOD/S.N.		Equipment	

FREQ MHZ	MEAS dBm	EQUIV dBμv	ATTEN dB	ANT FACTOR dB	TOTAL dBμv	TOTAL v/m	REMARKS
1000	-2	105	12	26	143	14	No malfunction
1100	5	112	12	27	151	35	" "
1200	-4	103	12	28	143	14	" "
1300	0	107	12	28	147	22	" "
1400	-3	104	12	29	145	18	" "
1500	-5	102	12	30	144	16	" "
1600	1	108	12	31	151	35	" "
1700	7	114	12	31	157	70	" "
1800	4	111	12	32	155	55	" "
1900	6	113	12	32	157	70	" "
2000	8	115	12	33	160	100	" "
3000	0	107	12	36	155	55	" "
4000	-13	94	12	39	145	18	" "
5000	-10	97	12	41	150	31	" "
6000	-10	97	12	43	152	40	" "
7000	-10	97	12	44	153	43	" "
8000	-9	98	12	45	155	55	" "
9000	-9	98	12	46	156	60	" "
11,000	-16	91	12	47	150	31	" "
	[illegible]						

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#12

Test: RS03 Radiated Susc. Date: 22 Sept. 1976

Manufacturer: Barnes #2 Task No.: 6072.00100

Item: Alarm System Operator: Scalsky.

MOD/S.N.: Equipment:

FREQ. MHz	MEAS dBm	EQUIV dBµV	ATTEN dB	ANT. FACTOR dB	TOTAL dBµV/m	TOTAL v/m		Remarks			
.014			0		140	10.		No malfunction			
								"		"	
								"		"	
30					140	10		"		"	
30					134	5		"		"	
								"		"	
								"		"	
1000			0		134	5		"		"	

#12

Test: RSO3 Radiated Susc
Date: 22 SEP 1976
Manufacturer: Barnes #2
Task No.: 6072,00100
Item: Alarm System
Operator: Scalsky
MOD/S.N.:
Equipment:

FREQ MHz	MEAS dbm	EQUIV dbuv	ATTEN dB	ANT FACTOR dB	TOTAL dbuv/m	TOTAL v/m		Remarks	
1000	-2	105	12	26	143	14		No malfunctions	
1100	5	112	12	27	151	35		"	"
1200	-4	103	12	28	143	14		"	"
1300	0	107	12	28	147	22		"	"
1400	-3	104	12	29	145	18		"	"
1500	-5	102	12	30	144	16		"	"
1600	1	108	12	31	151	35		"	"
1700	7	114	12	31	157	70		"	"
1800	4	111	12	32	155	55		"	"
1900	6	113	12	32	157	70		"	"
2000	8	115	12	33	160	100		"	"
3000	0	107	12	36	155	55		"	"
4000	-13	94	12	39	145	18		"	"
5000	-10	97	12	41	150	31		"	"
6000	-10	97	12	43	152	40		"	"
7000	-10	97	12	44	153	43		"	"
8000	-9	98	12	45	155	55		"	"
9000	-9	98	12	46	156	60		"	"
11,000	-16	91	12	47	150	31		"	"
	Above limits represent maximum equipment capabilities.								

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#13

Test	RS03 - Radiated Susc	Date	22 SEP. 1976
Manufacturer	ADL	Task No.	6072.00100
Item	Receiver- Inside	Operator	Scalsky
MOD/S.N.		Equipment	

FREQ. MHZ.	MEAS dBm	EQUIV dBuV	ATTEN dB	ANT FACTOR dB	TOTAL dBuV/m	TOTAL V/m		Remarks
.014			0		140	10.		No malfunctions
↓			↓		↓	↓		" "
↓			↓		↓	↓		" "
30			↓		140	10		" "
30			↓		134	5		" "
↓			↓		↓	↓		" "
↓			↓		↓	↓		" "
1000			0		134	5		" "

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#13

Test	RS03-Radiated Susc.	Date	22 SEP. 1976
Manufacturer	ADL	Task No.	6072-00106
Item	Receiver - Inside	Operator	Scalsky
MOD/S.N.		Equipment	

FREQ MHz	MEAS. dBm	EQUIV. dBμV	ATTEN. dB	ANT FACTOR dB	TOTAL dBμV/m	TOTAL V/m		Remarks				
1000	-2	105	12	26	143	14		No malfunctions				
1100	5	112	12	27	151	35		"			"	
1200	-4	103	12	28	143	14		"			"	
1300	0	107	12	28	147	22		"			"	
1400	-3	104	12	29	145	18		"			"	
1500	-5	102	12	30	144	16		"			"	
1600	1	108	12	31	151	35		"			"	
1700	7	114	12	31	157	70		"			"	
1800	4	111	12	32	155	55		"			"	
1900	6	113	12	32	157	70		"			"	
2000	8	115	12	33	160	100		"			"	
3000	0	107	12	36	155	55		"			"	
4000	-13	94	12	39	145	18		"			"	
5000	-10	97	12	41	150	31		"			"	
6000	-10	97	12	43	152	40		"			"	
7000	-10	97	12	44	153	43		"			"	
8000	-9	98	12	45	155	55		"			"	
9000	-9	98	12	46	156	60		"			"	
11,000	-11	91	12	47	150	31		"			"	
	Above levels represent maximum equipment limitations											

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#14

Test	RS03 - RADIATED SUSC.	Date	22 SEP 1976
Manufacturer	IRIS	Task No.	6072.00100
Item	ALARM. SYSTEM	Operator	SCALSKY
MOD/S.N.		Equipment	

FREQ MHZ	MEAS dBm	EQUIV dBuV	ATTEN. dB	ANT. FACTOR dB	TOTAL dBuv/m	TOTAL v/m		Remarks				
.014					140	10.		No malfunction				
								"			"	
								"			"	
30					140	10		"			"	
30					134	5		"			"	
								"			"	
								"			"	
1000					134	5		"			"	

#14

Test	RS03 - RADIATED Susc.	Date	22 SEP. 1976
Manufacturer	IRIS.	Task No.	6072. 00100
Item	ALARM SYSTEM	Operator	SCALSKY
MOD/S.N.		Equipment	

FREQ MHz	MEAS dBm	EQUIV dBµV	ATTEN. dB	ANT. FACTOR dB	TOTAL dBµV/m	TOTAL V/m	Remarks
1000	-2	105	12	26	143	14.	No malfunctions
1100	5	112	12	27	151	35	" "
1200	-4	103	12	28	143	14	" "
1300	0	107	12	28	147	22	" "
1400	-3	104	12	29	145	18	" "
1500	-5	102	12	30	144	16	" "
1600	1	108	12	31	151	35	" "
1700	7	114	12	31	157	70	" "
1800	4	113	12	32	155	55	" "
1900	6	115	12	32	157	70	" "
2000	8		12	33	160	100	" "
3000	0	107	12	36	155	55	" "
4000	-13	94	12	39	145	18	" "
5000	-10	97	12	41	150	31	" "
6000	-10	97	12	43	152	40	" "
7000	-10	97	12	44	153	43	" "
8000	-9	98	12	45	155	55	" "
9000	-9	98	12	46	156	60	" "
11,000	-16	91	12	47	150	31	" "
	[illegible]						

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